# SAE Journal

FEBRUARY 1959

IN THIS ISSUE . . .



Published by The Society of Automotive Engineers

1959 Technical Report No. 2

# Piston ring progress...*again*

When your heart is in what you do, you think about it quite a bit.

We at Perfect Circle think constantly about piston rings...better piston rings...better ways to make piston rings.

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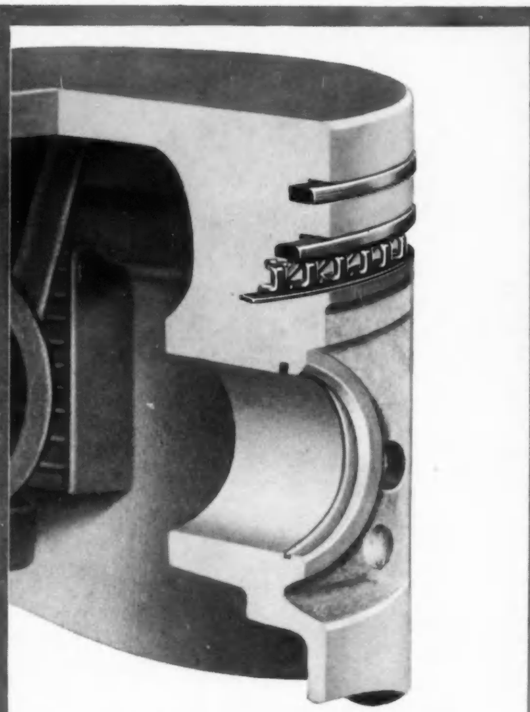

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To order papers on which articles are based, see p. 6.



READERSHIP RESEARCH

# CASE HISTORIES


Photo: Courtesy Warner Electric Brake & Clutch Co.

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## AIRCRAFT

**Factors Influencing Variable Inlet Control Designs, F. A. WILCOX. Paper No. 81C** presented Sept.–Oct. 1958 12 p. Carefully designed automatic control required to position inlet variable features for steady level flight, and for disturbing influences such as gusts, armament firing, and changes in engine air flow of turbojet aircraft; several methods of sensing inlet operating condition; determination of dynamic behavior of all parts of loop, especially inlet whose dynamics are combination of dead time and fillup lag.

**Evaluation of Ground-Level Escape System, F. P. MARCINIAK, R. A. HOUGHTON. Paper No. 91A** presented Sept.–Oct. 1958 21 p, 1 folding sheet. Evaluation program of Martin-Baker ejection seat Type Mark A5 for US Navy; analysis of test data includes ejection, trajectory, and impact phase; physiological analysis; it is indicated that seat qualifies as escape in Grumman F9F-8T jet trainer at ground level within speed range of 95 to 450 knots at angles of yaw up to 15° and 4° respectively.

**Developments in Field of Direct-Air-Cycle Aircraft Nuclear Propulsion Systems, H. MILLER. Paper No. 92B** presented Sept.–Oct. 1958 14 p. Progress report deals with General Electric's heat transfer reactor experiment No. 1 (HTRE-1) designed to test and verify design of nuclear system; HTRE power plant consists of air cooled, metallic-fuel-element, water moderated reactor operating turbojet engine; nuclear power testing facility at Idaho Test Station; radioactive materials laboratory.

**Radiation Effects Testing of Aircraft Systems, M. M. MILLER, A. M. LIEBSCHUTZ. Paper No. 92C** presented Sept.–Oct. 1958 7 p. To evaluate performance of systems in nuclear powered aircraft, tests of operating system must be conducted under conditions simulating those expected to exist during flight; environmental factors and requirements for conducting irradiations on dynamic systems; requirements for test facility capabilities and facility meeting these requirements; sequence of operations for typical test program.

**Nike Hydro-Mechanical Maintenance Problems, H. J. IDE. Paper No. 93B** presented Sept.–Oct. 1958 6 p. General approach and experience in maintaining hydraulic, pneumatic and mechanical components and systems of both Nike Ajax and Nike Hercules missiles and their ground support equipment; problems of education and communication; handling and contamination problems, difficulties arising from inadequate design illustrated by examples.

**Maintainability of Falcon Missile System, R. W. MANLEY. Paper No. 93C** presented Sept.–Oct. 1958 9 p. Missile ground support system and its relationship to maintainability; approach and steps taken in evolution of maintenance system with respect to development of original Falcon, GAR-1; formulation of concept and design objectives; design of hardware; tactical use of system and feed-back of information; summary of field experience.

**Adaptation of Constant Speed Drives**

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## Briefs of SAE PAPERS

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**to Long Range Manned Aircraft of Immediate Future, C. W. HESLEY, Jr. Paper No. 94A** presented Sept.–Oct. 1958 17 p. Constant speed drive (CSD) defined as any device which extracts power from independently variable energy source; discussion confined to manned aircraft turbojet powered with flight speeds from Mach 2.5 to 4.0; adaptation of constant speed drives to aircraft environment; hydraulic and mechanical CSD types.

**Turbonator — Integrated Air Turbine Generator for High Mach Aircraft, S. F. RICHARDSON, J. W. HAYNES. Paper No. 94B** presented Sept.–Oct. 1958 8 p. Machine combines air turbines' power producing and air conditioning characteristics in single package, designed to produce high quality electric power without necessity for providing external cooling; ambient free characteristics of Turbonator make it practical to locate it in any area of aircraft; possibilities discussed of its use in nuclear atmospheres and for certain outer atmosphere vehicles.

**Constant Speed Drives for High Mach Aircraft, F. L. MONCHER, J. S. CARDILLO. Paper No. 94C** presented Sept.–Oct. 1958 22 p. Increased requirement for a-c electric power with closely regulated frequency dictates need for high performance constant speed drives; use of hydraulic transmissions proposed; new design concept in hydraulic pumps and motors; differential package drive.

**Mechanical Consideration in Design of Constant Speed Transmission for Mach 3 Applications, D. L. CAUBLE, K. A. TEUMER, J. G. CASTOR. Paper No. 94D** presented Sept.–Oct. 1958 16 p. Constant speed drive defined as machine converting variable speed shaft input power to constant output power suitable for driving synchronous generator; hydrostatic differential constant speed drive used to illustrate mechanical component problems and means for solving problems encountered at higher temperatures.

**Jet Engine Control and Attitude Control in Vertical Attitude VTOL Aircraft, J. W. BAXTER, R. C. FINVOLD. Paper No. 95A** presented Sept.–Oct. 1958 13 p. Experience at Ryan Aeronautical Co, with engine thrust control as applied to VTOL aircraft; satisfactory application of non-afterburning engine in USAF X-13 aircraft; future problem areas examined for application of afterburning engines; control problems unique to all VTOL and vertical attitude concept in particular; altitude and attitude stabilization requirements.

**X-14 VTOL Airplane — Design Tool, J. A. O'MALLEY, Jr. Paper No. 95B** presented Sept.–Oct. 1958 18 p. Background of original Air Test Vehicle and development of USAF research aircraft of horizontal attitude type, by Bell Aircraft Corp; two power plants are Armstrong-Siddeley "Viper" engines, possessing rated 150-hr life; ground pressure and ground heating effects; thrust diverter development; STOL and conventional flight performance; stability and control; future potential.

**Some Thoughts on Optimum Combinations of Wings and Vertical Thrust Generators in VTOL Aircraft, W. Z. STEPNIEWSKI. Paper No. 95C** presented Sept.–Oct. 1958 19 p. Review of VTOL problems to indicate probable ways toward optimization of whole lifting and propelling system; power and thrust requirements for optimum cruise and vertical take-offs and landings for propeller type and jet propelled aircraft; thrust generating system and hovering fuel weight; vertical thrust generator plus wing system.

### FUELS & LUBRICANTS

**Behavior of Radiation Resistant ANP Turbine Lubricants, J. M. CLARK, Jr., G. C. LAWRASON. Paper No. 92D** presented Sept.–Oct. 1958 17 p. Study, made at Southwest Research Inst, of problems involved in testing lubricants under dynamic conditions supplemented by additional stress of high level radiation; test facility using Cobalt-60 emitting gamma radiation as source; testing conditions employed

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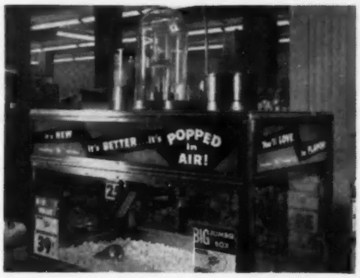
But this corn popper *is a first*—to the best of our knowledge.




This machine pops corn with *hot* air—and all the action takes place *before your eyes*.

But that's putting the cart before the horse, because it was quite a number of moons ago when the designers at Electri-Cooker Division of General Foods were at the idea-developing stage.

They wanted a *new* way of popping corn. And they wanted to boost sales by having all the popping parts *visible*.

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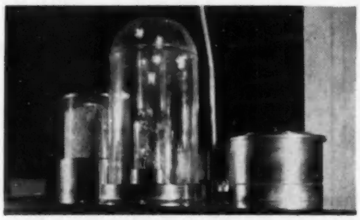
And Corning in turn came up with a number of key components made from a PYREX brand glass. Included are a 17-inch display dome, 13-inch lamp chimney, and an 8-inch chamber for storing unpopped corn.



Why a PYREX brand glass? Because you can use it at elevated temperatures without worrying about thermal shock. (For example, PYREX brand glass No. 7740 has a linear coefficient of expansion of 32.5 x $10^{-7}$ in./in. between 0° and 300° C.)

Also, you can see through glass (an obvious but still extremely useful feature).

And glass is so easy to keep clean, there's no place for dirt to lodge in its *smooth* surface. Glass No. 7740 also is resistant to the attacks of most acids and alkalies and stands up well under distilled water.

You can find machines dispensing corn popped by hot air at Woolworth's, Grant's, Kresge's, McCrory's, Newberry's and Sears Roebuck & Company. You can find *glass* answers to one of your materials or component problems by coming to Corning.

You can get a head start by perusing "This Is Glass," a 64-page, well-illustrated primer. And/or ask for Bulletin B-83, a detailing of mechanical, thermal, electrical, and chemical properties for three of Corning's most popular types of glass. Use the coupon.

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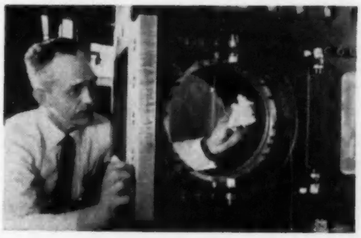

**Optical purity and a high softening point (1585° C.) make Corning's 100% Fused Silica useful in wind tunnel windows.**

Fused Silica also is used in ultrasonic delay lines, being well suited for handling delays ranging from 10 to 16,000 microseconds. More: You'll find this material possessed of high electrical breakdown resistance, low dielectric loss, and low expansion. And it is permeable to helium.

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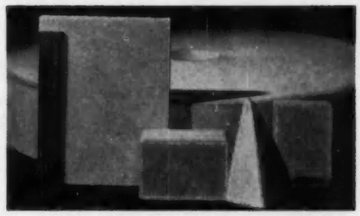

The material used to make these objects has 1500 square feet of surface area per cubic foot. Individual wall thickness averages only 0.005 inch; weight is only 30 pounds per cubic foot.

This material can withstand temperatures up to 1800° F. with virtually no thermal expansion, and can be operated continuously at 1290° F. At either temperature you don't have to worry about thermal shock or oxidation.

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# For the Sake of Argument

## Ever See a Statue for a Critic?

SOMETHING ABOUT HUMAN NATURE stirs us to oppose what we dislike faster than to support what we favor. We spring to stop our enemies quicker than to support our friends. When we're *for* something, we give it strong tacit support. When against it, we howl our condemnations.

Irritation bubbles from most of us noisily, while gratitude slips out quietly. Anger boils many degrees lower than appreciation — as far as vocal or written expression is concerned. The idea clings that exposing the other fellow's faults may cover up our own.

Perhaps opposing takes less thinking than supporting. It's easier to formulate a criticism than a prayer; easier to wreck a house than to build a cathedral.

Infrequently do we give thanks when required neither by etiquette nor policy. So, we deny ourselves the gratitude which, almost inevitably, responds to unexpected praise. For ten who take pen in hand to complain about services rendered, but one will raise the roof about being satisfied.

Praising the positive gives us a sense of participating in something good. . . . And participation in something good always brings satisfactions. We live our way into life's best values. Gilbert Chesterton sought "to remind men that things must be loved first and improved afterwards."

"When things go wrong, don't go with them," a wayside philosopher urged the other day. He might have added: "Take time to make the good better. Don't waste too much of it fighting the bad."

Norman G. Shidle

# chips

## from SAE meetings, members, and committees

**1959 SAE Annual Meeting**
**. . . see report starting on page 84 of this issue.**

**HIGH COST OF FLYING** — Thirty years ago, when a single-engine monoplane made a 600-mile trip in Peru to inaugurate Panagra's (Pan American-Grace Airways) air service in South America, the total U. S. aircraft production was 1857 planes valued at $12,024,085. Today, that amount would pay for about half of the five DC-8 jets which Panagra has on order.

**NO ENGINEER IS INSPIRED** to do his best work unless he can communicate, says General Dynamics' Senior VP-Engineering L. P. Richardson. "He must have the opportunity to receive knowledge — to learn what is going on — to express himself. Lack of effective communication leads only to misunderstandings and frustrations which badly impair efficiency. . . . Good communication does much to create another incentive — the sense of belonging, the feeling of being a part of the enterprise."

**ONLY 30% OF A POPULAR SPORTSCAR** should have been satisfied by the highest octane premium-grade gasoline being marketed in Ohio in 1955, according to the octane requirement distribution curve, E. H. Scott and H. F. Hostetler of Standard Oil Co. (Ohio) recently revealed. As a matter of fact, they found that "thousands" of these sportsters were speeding over Ohio roads using this fuel, with no noise problems. It is evidence such as this, Scott and Hostetler pointed out, that has made many petroleum and automotive companies, as well as CRC, question the ability of the current octane requirement technique to validate the customer's reaction to various antiknock level fuels in his car.

**ONE HYDRAULIC FLUID** for passenger cars is the goal of a new Fuels & Lubricants Technical Subcommittee. The fluid, used in centralized systems would power such parts as: power brakes, power steering, and the brake system itself.

Automotive engineers are pooling their knowledge of hydraulic fluid environment so that the research laboratories of the fluid manufacturers will have a single goal to meet. Through this cooperation, it is anticipated that the characteristics of a single fluid can be established for the benefit of the automotive design engineers who are developing the components in which it may be used.

It is expected that the engineering information will be presented as a series of minimum performance tests that will show if a particular fluid will operate satisfactorily in the central hydraulic systems of future cars. One of the advantages of this work is the exchange of this engineering information *before* the problem arises in the field.

**ELEVEN DAYS CUT TO ELEVEN HOURS** — The new Douglas DC-8 jets which Panagra will place into service in another year, will make the flight from New York to Buenos Aires in about 11 hours compared to the 11 days it took when Panagra pioneered the route three decades ago.

**SHADES OF CAPITALISM** — Special cash payments are made to inventors in Russia says Wayne Worthington of John Deere who recently returned from a trip to the USSR.

The man who developed a tractor mower, which later went into successful production, received the maximum cash award of 200,000 rubles. The maximum payment for an "idea" which leads to successful development is 20,000 rubles. A total of 17,000 incentive payments were made to Russian agricultural engineers in 1957. (The official money exchange rate is 4 rubles to the U. S. dollar. Tourists, however, receive a special exchange rate of 10 rubles per dollar which is closer to actual buying power.)

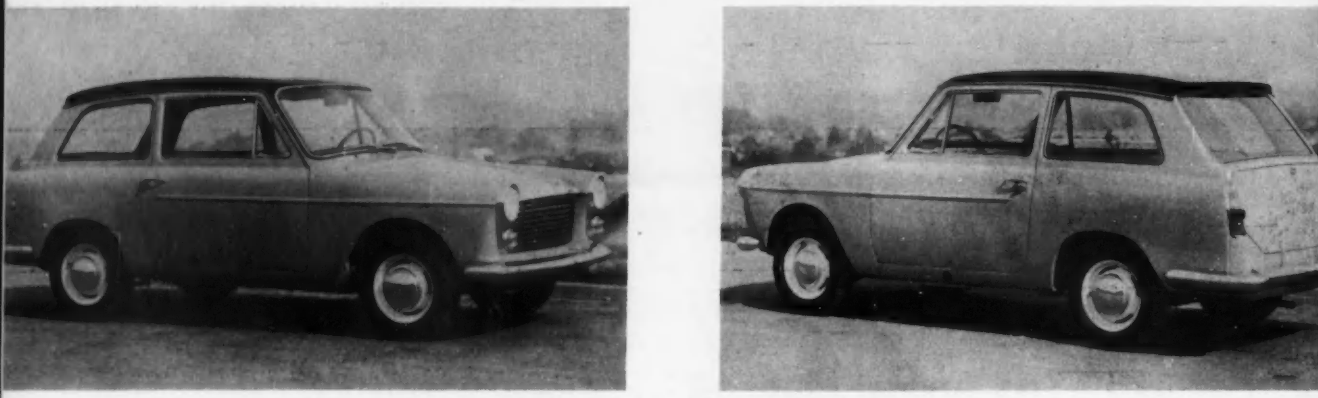

Fig. 1 — 1959 Austin A40 — Pinin Farina styled sedan/station wagon.

## New car designs, disc brakes, and automatic transmissions

# 1959 European Automobile

**Written especially for SAE Journal, this article is an interpretive analysis of current European design trends by an SAE member who has followed those trends closely for many years.**

by

**Aubrey Pershouse**

General Motors Overseas Operations

AS 1958 was an off-year for the Frankfurt Show, and as Turin now seems to be firmly established at the end of the year instead of in the early spring, the period of October 3 to November 16 in 1958 saw the three shows of Paris, London, and Turin, in that order. Attendance at Paris dropped some 6% compared with 1957, London was up about 11%, while at Turin it improved appreciably.

### important new models

With Frankfurt out of the picture, new models of German source were not very numerous. About the usual variety of new, or partially new, models from all the other European sources made their appearance, however. Some appeared at the shows themselves, some in the course of the year before October.

Of the really brand new models of large, or potentially large, volume, the British Austin A40 sedan/station wagon combined, is probably the most important. (See Fig. 1.) This car, which uses the smallest 4-cyl, 948 cc (57.8 cu in.) engine in the British Motor Corp. range, provides a rather unusual combination of small sedan and station wagon features and has a simple, sturdy appearance which owes something to Italian styling influence. Other English newcomers included Rover 3 Litre, Humber Super Snipe, Aston Martin DB4, Jaguar Mark IX, and besides a variety of face-lifts for well-known types, some new small production volume cars with fiber-glass bodies such as Opperman and Peerless.

In Germany the Opel Kapitan, the Mercedes 190D, new features of other Mercedes models, and deluxe models of Goggomobil, Lloyd, and N.S.U.-Prinz all deserve comment.

Among French cars, while the station wagons offered on the I.D. 19 Citroen chassis were new, and while Simca showed new bodies on certain models in the Aronde range, the most interesting and attractive newcomer was the Renault Floride (shown in Fig. 2), which will not be in production until some way into 1959. This car, using Renault Dauphine mechanical components, will be available in open and hard-top forms with a body styled by Frua. The body is to be made by Chausson and assembly carried out by a third firm near Paris. Since Renault is a nationalized firm, this planned cooperation between private enterprise and government seems worthy of note.

It is proposed to sell the Floride in France at a

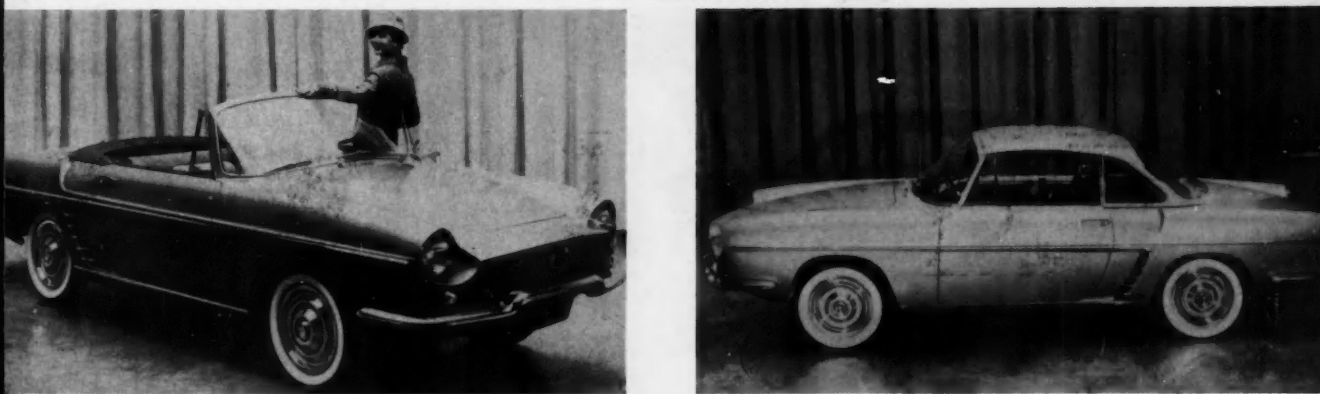

Fig. 2 — 1959 Renault Floride.

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# Trends

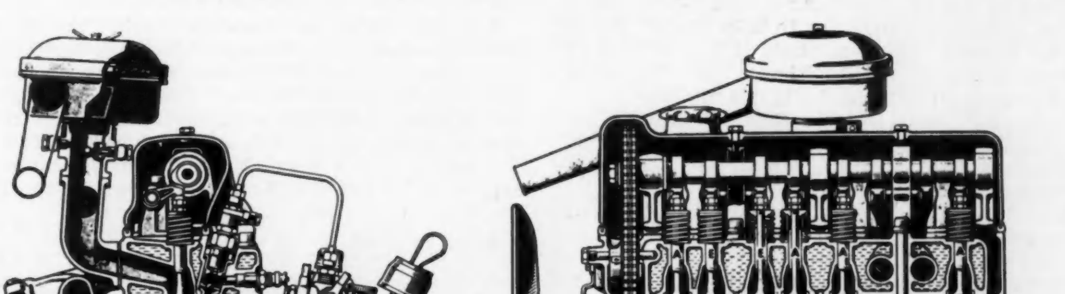

Fig. 3 — Section of new Mercedes diesel (190D) with single overhead camshaft.

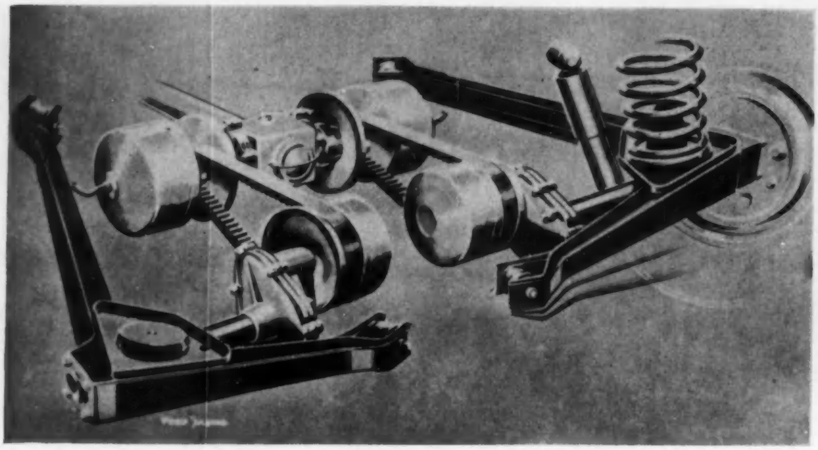

Fig. 4. — Prototype DAF Variomatic belt and pulley transmission.

## 1959

## European Automobile Trends

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price in the neighborhood of Fr. frs. 850,000 ($2024) without the detachable hard-top.

There were no new potentially high volume models at the Turin Show.

### use of Italian stylists

The interest aroused by the Renault Floride points up a trend which was quite noticeable in the 1958 European Shows; namely, the use of Italian body-designers by the European car industry generally to produce new body designs or to help impart glamor to older models. Obvious cases of this nature include, in addition to the Floride, the following: English Standard Vanguard-Vignale models (Michelotti), English Aston-Martin DB4 (Touring), German N.S.U.-Prinz sport coupe (Bertone), German Lloyd sports coupe (Frua), Austin A40 sedan/station wagon (Pinin-Farina).

While some of the results are excellent, it should be observed that in one or two cases they do not have the glamor which the association of some of the above names might be taken to imply. Turin demonstrated an increasing interchange between U. S. makers and the Italian body-building industry.

### minicar trends

The continued importance of very small cars in the European production picture was commented on in the article on the 1957 shows (SAE Journal, February 1958).

At the 1958 shows there were no outstanding interesting new makes of this type, with the exception of the Dutch DAF prototype, which is not yet in production. However, the previously noted trend towards larger, more complicated and more expensive models — while the basically simple volume models tend to continue in production — is still evident. Examples of this are the Lloyd Alexander TS, the Lloyd Frua coupe, the Goggomobil 700, and the N.S.U.-Prinz sport coupe. Of last year's newcomers in the minicar category the French Vespa and the German BMW 600 and N.S.U.-Prinz models all appear to be very successful.

### antiglare finish on instrument panels

At all three shows a number of cars were noticed on which makers had taken commendable pains to minimize glare from the top of instrument panels by providing a mat, dark finish at this point. In addition to many of the U. S. exhibits, this was seen on the following makes and models: Alfa Romeo, some of the Austin and English Ford models, Humber, some of the Morris models, Vauxhall Cresta, Aston-Martin, Standard Pennant, and others.

### diesel engines in passenger cars

For some years now the Mercedes 180D model has been the outstanding successful diesel-powered European passenger car. While continuing production of this 4-cyl model of 1767 cc (107.8 cu in.), Mercedes has introduced for 1959 a diesel engine option in the next more expensive, 190, series of passenger cars. This comprises a 4-cyl, single overhead camshaft engine of 1897 cc (115.7 cu in.) displacement. (See Fig. 3.) It is claimed that this engine is quiet, smooth, and flexible up to some 75 mph. Additional European interest in diesel-powered passenger cars is evidenced by the fact that Austin recently brought out a new vehicle designed for taxi or hire-car work, which is also equipped with a 4-cyl 2.2 litre (134 cu in.) diesel engine.

### disc brakes

The British industry for some years now has been the protagonist of disc brakes to obviate fade in hard usage. To start with, the use of these was limited to actual competition road-racing cars but it has gradually extended down to the cheaper sports models and up to some of the high-priced luxury cars. It is significant that such a conservative maker as Daimler showed their new Majestic model with disc brakes all-round at Earl's Court this year, while other new models in 1958, having discs either at the front only or on all four wheels, were: Aston-Martin DB4, Peerless, Armstrong Siddeley Sapphire, M.G.A. Twin-cam, and Bristol 406.

Dunlop and Girling are the chief suppliers of disc brakes for British cars. Lockheed advertises a disc brake in England, but at present this is only in use on the B.R.M. Formula 1 racing car. It will be interesting to see whether, over the next few years, any of the makers of small high volume sedans take up this type of brake. It is felt that the hesitant attitude of most volume producers so far towards the disc brake stems from the inevitably higher cost of this system compared with drum brakes.

Since the European Shows Ferrari has announced that it will use disc brakes on its 1959 2-Litre V6 sports-racing model. This specialized Italian firm, long a hold-out for drum brakes in the competition world, has also been trying out disc brakes of English source on its Formula 1 Grand Prix racing cars.

## declining interest in automatic clutches

1956 and 1957 were the years in which many English and some German makers made a great fanfare of offering "2-pedal control" by means of various devices which permitted manual gear-changing without any declutching action on the part of the driver. There were a few Continental recruits to these optional devices during 1958, such as the small volume Lancia Appia and Flaminia models and the considerably more important Opel Rekord which, in the German market only, offers a very well worked out variation of the Saxomat device. The German BMW 600 minicar also offered this clutch as an optional extra in October 1958.

Amongst English makers on the other hand, Morris withdrew their 2-pedal option on the 1489 cc (90.86 cu in.) Oxford model, while there was an entire absence of emphasis on these devices in all the publicity surrounding the 1958 Earl's Court Show. It is felt that there is a real and deep interest in the European industry generally concerning the possibility of a genuine automatic transmission that would function with small output engines, not constitute too great a cost increment, and avoid any increase in fuel consumption compared with transmissions now in use.

## automatic transmissions

In the SAE Journal article of February 1958, the interesting MIRA transmission, which is under development and test by the British Motor Industry Research Association, was described at some length. As yet, no car manufacturer has adopted this device which, in many ways, is well suited for operation with small engines. However, the Association states that development work is continuing, and that there is some possibility of starting to examine whether one of these transmissions can be worked out which would be suitable for engines of well under 1000 cc (61.0 cu in.).

## Simca-Rushmatic transmission

At the Paris Show Simca Vedette models were offered with an optional Rushmatic transmission having some of the features of an automatic.

This arrangement includes the normal Vedette 3-speed gearbox and a large reduction rear axle (used otherwise on the station wagon models). Between these two components, an English-type Laycock de Normanville automatic overdrive unit is installed whose operation, in the case of the Rushmatic, is controlled by two pushbuttons.

This well-known overdrive unit consists of a planetary gearset with hydraulically operated cone clutches, which engage either third gear (direct) or a geared-up fourth speed.

The driver makes normal clutch and manual lever changes up to, and into, third speed. From that point on, the Rushmatic comes into operation. In the Rushmatic, a centrifugal governor, connected with the speedometer drive, makes the gear changes in a manner depending on the driver's pushbutton selection. Depression of the lower button, which is marked "Route," ensures that the governor will pick up the fourth overdrive, at as low as 30 mph, third will re-engage below this speed or, when the driver kicks down the accelerator, at any point before the car reaches some 67 mph. On the other hand, continued full pressure on the accelerator means that third will be in operation continually until 67 mph is reached, when overdrive will be engaged. In fact, depressing the "Route" button gives the driver a choice of automatic gear changes between third and fourth in the speed range of 30–67 mph ,the selection of these gears being dependent on his actions with the accelerator pedal.

If the driver depresses the "Rush" button, fourth

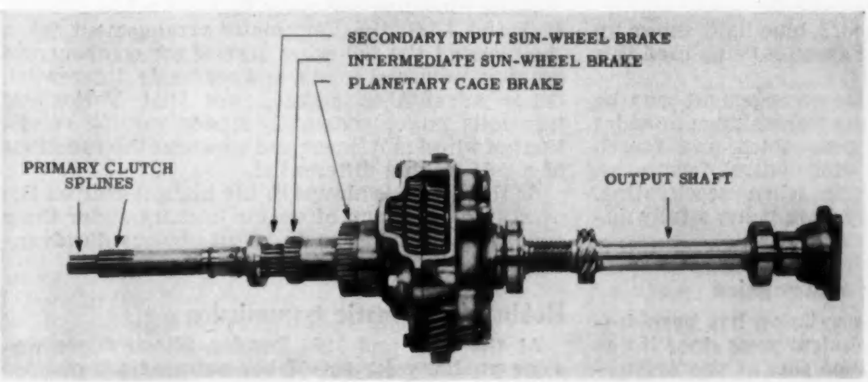


Fig. 5 — Gear unit of Hobbs transmission.

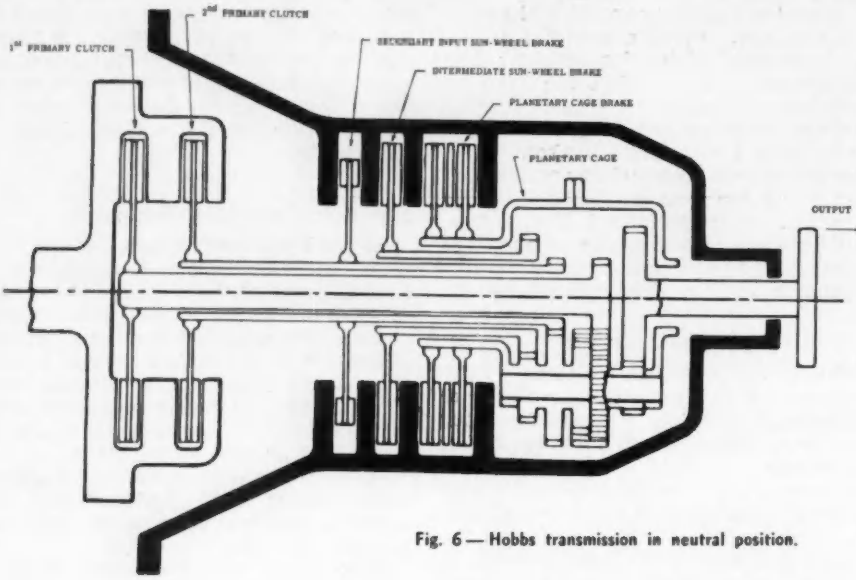


Fig. 6 — Hobbs transmission in neutral position.

# 1959

## European Automobile Trends

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(overdrive) will not come into operation until 67 mph is reached and third will re-engage when car speed falls to just over 50 mph.

There is, in addition, a manifold-vacuum operated method of engaging third from overdrive for overrun engine braking on long descents.

When overdrive is engaged, a blue light shows up on the dash and when third speed is being used this is green.

In practice this Rushmatic arrangement may be summed up by saying that the transmission provides an automatic change between third and fourth gears and that, by an overriding control, fourth can be eliminated below 67 mph when accelerating. This, of course, is a long way from being a fully automatic transmission.

### Dutch DAF — Variomatic transmission

The DAF Variomatic transmission has been frequently described in the technical press since it was first shown with the prototype cars at the Amsterdam Show in February 1958. For this reason this transmission will not be described in any great detail. The device, as shown in Fig. 4, starts with a centrifugal clutch and thence depends upon the old principle of V-belts running between pulleys that expand and contract. Movement of the front and rear pulleys is controlled by centrifugal weights reinforced, in the case of the front pulleys, by manifold-vacuum. It is claimed that the old belt slippage troubles have been eliminated by the use of modern materials in belts and pulleys and that even though the mechanism is exposed to the elements, no difficulties have been experienced during a lengthy testing period in all kinds of weather.

While providing infinitely variable ratios between 20/1 and 4.4/1, the Variomatic arrangement takes the place of the following normal car components: gearbox, universal joints, and rear-axle differential. Other advantages claimed are that Variomatic transmits power constantly under varying conditions of wheel movement and performs the functions of a self-locking differential.

As the device is always in the highest gear on the overrun a minimum of engine braking under these conditions would seem to be an obvious disadvantage.

### Hobbs Mecha-matic transmission

At the 1954 and 1955 London Shows there was some publicity for the Hobbs automatic transmis-

sion, which was offered at that time as an option on the Lanchester 1622 cc (99 cu in.) Sprite car, which shortly thereafter disappeared from production.

The Hobbs Transmission Co., which is a subsidiary of B.S.A. (Birmingham Small Arms), appeared at the 1958 Earls Court Show as an independent exhibitor. Although no British passenger-car makers currently use the transmission, refinements have been made since its first appearance and it has been successfully operated in a larger form in a fleet of buses for some years now.

The interest of the Mecha-matic transmission lies in the fact that its power transmission is mechanical and not hydraulic, which, of course, makes it of interest as a transmission for use with small engines, where the usual power losses with hydraulic transmissions are inadmissible. It is claimed that the Mecha-matic can be produced to compare in bulk and weight with a normal synchromesh transmission and that cost would compare favorably with other types of automatic drive.

The Mecha-matic is particularly economical when running in top gear, as drive is then straight through without even the encumbrance of an idling layshaft. The makers claim that better fuel consumption is obtained than with a synchromesh box.

The system consists of a single compound planetary gear train having no ring gear and five wet friction clutches. Two of these clutches engage the engine flywheel and therefore transmit drive, the other three engage stationary discs and act as reaction brakes. (See Fig. 5.)

The planetary train is driven by alternative input sun gears (primary and secondary); each takes engine drive via one of the two independently operated primary drive clutches.

Output is via a sun wheel at the rear of the epicylic train and there is a further sun wheel, which is intermediate in effect, being on neither an input nor an output shaft. The second input sun wheel, the planetary cage, and the fourth intermediate sun wheel can each be locked by the three independently operated brakes. Changes in ratio are achieved by varying the application of the two clutches and the three brakes. Hydraulically actuated pressure plates engage and disengage these clutches and brakes, all five of which are basically similar in design and actuation; all are of the single-plate type, except for the planetary cage brake, which has twin-plates.

Neutral, as shown in Fig. 6, is achieved by disengaging both clutches and freeing all three brakes and the other ratios by the operation of valves under direct oil pressure to actuate the brakes and clutches as needed.

At engine idling speeds all clutches and brakes are free and there is no drive to the wheels. Drive is taken up by directing oil under pressure to activate the particular brake and clutch combination, which brings the gear into effect, usually of course first or reverse gear, for which the twin-plate brake is employed, in conjunction with one of the two primary clutches.

Change of ratio can be automatic or manually selected or both.

The manual control lever has seven positions — reverse, neutral, first, second, third, top, and automatic.

Automatic control of the four forward ratios is governed by oil pressure acting on a plunger and overcoming spring pressure opposing it, as shown in Fig. 7. The movement of the plunger opens and closes the appropriate circuits as the oil pressure rises or falls, and is governed by two factors: engine speed and therefore oil pump speed and delivery pressure, and the size of an oil escape jet.

With the escape jet constant, changes take place at the predetermined engine speeds. By increasing the escape jet size, changes are delayed, or in other words the engine speeds at which changes take place are raised, and vice versa. An interconnection between accelerator pedal linkage and the transmission control valve can be used to increase or diminish the escape jet size, thereby delaying or advancing the gear shift points according to throttle openings at the time.

The result of this is that automatic gear selection is governed primarily by engine speed but also to a secondary extent by the throttle position and therefore by engine torque.

One of the popular BMC products, a Morris-Oxford 1489 cc (90.86 cu in.) sedan, fitted experimentally with this device was driven some miles in varying conditions of London traffic.

Under these circumstaces, which called for frequent stops and accelerations on the level, the Mecha-matic functioned well as a fully automatic transmission and was noticeably smooth and silent. Movement from a standstill was somewhat abrupt but familiarity with this tendency rapidly permitted its being overcome by careful accelerator operation. The firm's representative stated that a more gentle pickup of the initial drive could readily be obtained, if required, by means of adjustment to the control system.

It will be of considerable interest to note, when the 1959 year-end automobile shows take place, whether any important makers have proceeded further with either the MIRA or Mecha-matic transmissions.

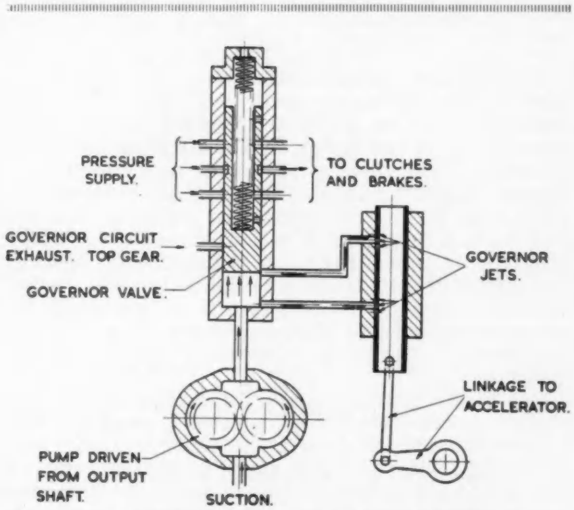



Fig. 7 — Hobbs transmission automatic control system.

# Shielding Experiments for Nuclear Aircraft Are Conducted:

## • High up on towers. • In the air. • On the ground.

Based on paper by

**N. M. Schaeffer and R. L. French**

Convair-Fort Worth, Division of General Dynamics Corp.

THREE years of ground-level and in-flight testing of a nuclear reactor have provided the information needed:

- To design shielding for nuclear-propelled aircraft. Estimates indicate that the shield weight can now be predicted for a particular design with an uncertainty of ± 15%.

- To predict rather closely the radiation environment expected at any given position on the airplane.

## Program

Prior to the airborne shielding program, calculation of the various radiation transfer processes for divided-shield systems was subject to considerable uncertainty because of insufficient input data and because of the simplifications necessary for calculation.

A clear understanding of these processes did not appear to be forthcoming from the shielding experiments conducted at ground level alone because they invariably were complicated by interaction of the radiation with the ground. Thus, the best approach was to obtain data with a fully engineered system operated under realistic environmental conditions, that is, in flight.

Even after elimination of ground effects, however, it was often difficult to analyze the data sufficiently. For example, the relative effects of air scattering and structure scattering in the nuclear test aircraft could be measured only by indirect means.

Thus, a third type of experimental arrangement was required — one that allowed measurements with the reactor and shield system in the air, but in the absence of both ground and airplane structure. Such an arrangement was obtained by suspending the structure from towers high enough in the air for ground effects to be negligible.

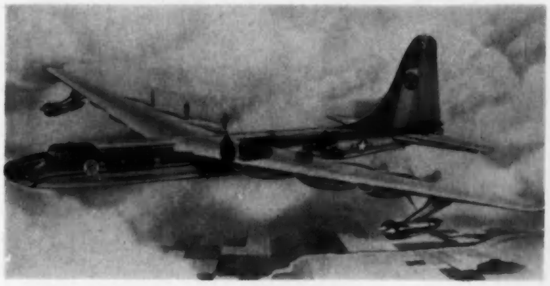
The nuclear test airplane is depicted on page 33. Other equipment used in the tests is shown in Figs. 1–6.

**Ground-Level Experiments** — One of the most important steps in the design or evaluation of an aircraft shield system is to determine the intensity and distribution of the radiation leaking from the reactor shield. The radiation intensity as a function of angle is called the "source term" of the shielded reactor (Fig. 7). The experimental technique for determining the leakage is called "direct beam mapping"; that is, the radiation is mapped by making measurements at small angular intervals. Axial symmetry may usually be assumed, so that measurements need be made only in a single plane through the reactor shield axis (normally the horizontal midplane).

One of the main purposes of the ground-level experiments conducted with the ASTR was to determine the source terms for the various shield configurations. Mapping was accomplished by rotating the ASTR on a special turntable while measurements were made at fixed positions. Other experiments were performed to measure air and ground scattering and to observe the effect of the NTA

**ON Feb. 13, 1956, at 15,000 ft over the New Mexico desert, a reactor was operated in flight for the first time. The flight was the first of a series made with the aircraft shield test reactor (ASTR) aboard the nuclear test airplane (NTA), a conventionally powered modified B-36H.**

**The nose section of the plane was completely re-engineered to accommodate a shielded compartment for protection of the crew during reactor operation. The aft bombbay was fitted with a mounting and special water and electronic quick-disconnect panels for the ASTR. Reactor heat was removed and dissipated into the air by a water-air heat exchanger system in the rear of the reactor bay. An instrument capsule formed the nucleus of the gamma and fast neutron dosimeter system designed to record radiation intensity at various points aboard the airplane.**



**Described here are the in-flight experiments and also the associated ground-level experiments, which comprised the Airborne Shielding Program. Although the reactor was used only as a source of radiation, many considerations for the experiments reflect the same problems (on a smaller scale) that must be solved for an aircraft propulsion reactor.**

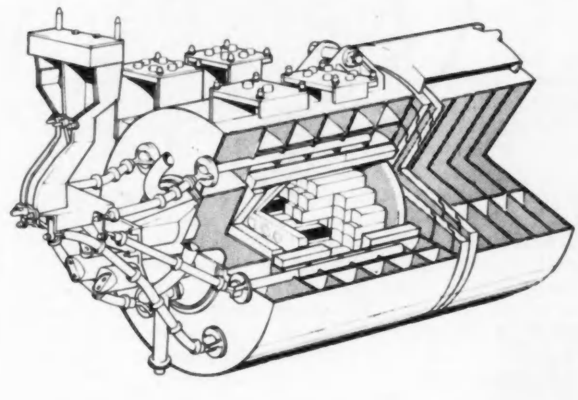
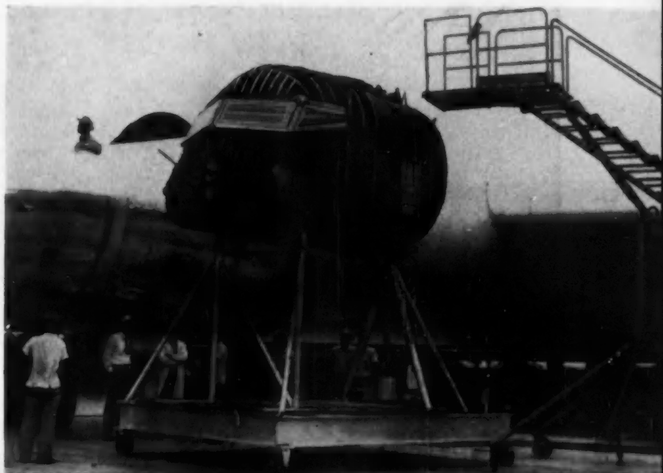


Fig. 1 — Aircraft shield test reactor is a 1000-kw reactor, cooled, moderated, and reflected by water. Core is made up of MTR-type enriched uranium fuel elements mounted between two plates and contained within a stainless-steel pressure vessel. Control system was designed so that reactor might be operated in any position.

Shield of lead and water surrounds pressure vessel. Water portion of shield may be varied by emptying or filling various compartments in shield tank. Some degree of flexibility in lead shielding is afforded by removable lead rings. Outer surfaces of ASTR shield are covered by boral to suppress leakage of thermal neutrons.

Fig. 2 — Shielded compartment for five-man crew: pilot, copilot, flight engineer, test engineer, and reactor engineer. Compartment weighed 23,000 lb, was about 12 ft long and 6 ft in diameter. Rubber, which has shielding characteristics similar to water, was used for neutron shielding, lead for gamma shielding.

Between ASTR and crew compartment was a simulated crew shield, called the "test cylinder," which had provisions for varying the thickness of rubber on its sides. A right circular cylindrical shape was used for convenience — to vary the wall thickness and facilitate data analysis.



# Nuclear Aircraft

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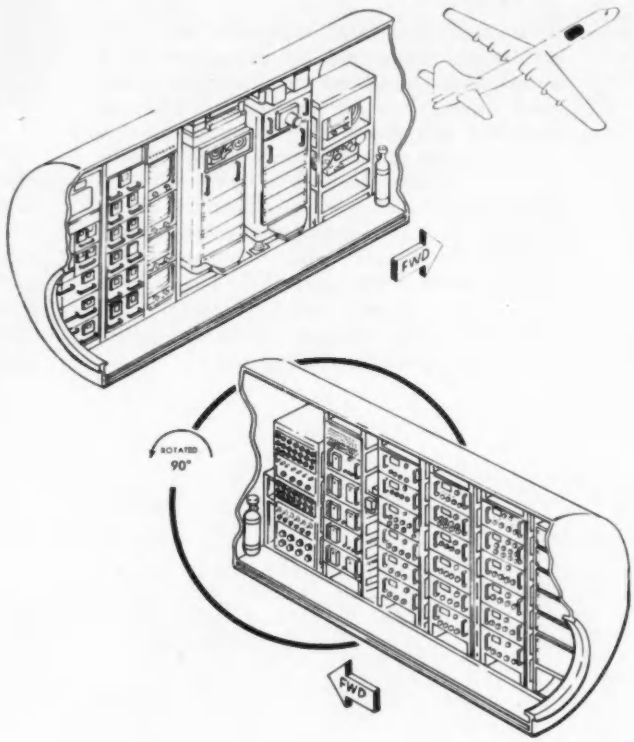


Fig. 3 — Shielded capsule behind crew compartment contained most of instrumentation. In all, 20 channels of instrumentation were provided. Since manual operation of such a large system could not be accomplished by the small crew, automatic recording equipment was used to store data on magnetic tape for readout after each flight.

Fast neutron and gamma dosimeters were placed in the shielded crew compartment, in the small cylinder, and at several locations along the aircraft fuselage centerline. Locations were selected to observe effects of different structural environments and to provide data to show dependence of dose rate upon separation distance from reactor.

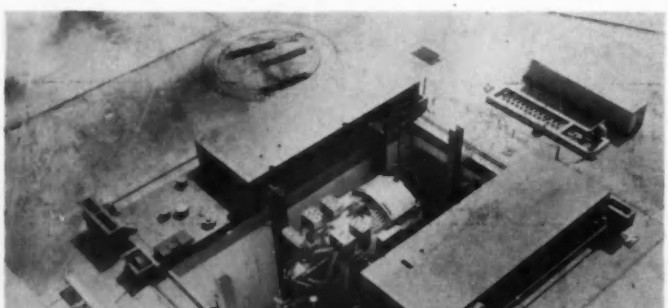

Fig. 4 — Nuclear reactor was loaded into plane when latter was positioned over loading pit, which also served as storage location for ASTR. With shield cover rolled back on tracks, ASTR was raised from pit by hydraulic mechanism and locked into position in NTA.

To facilitate alignment of ASTR with NTA, loading mechanism had four degrees of freedom. A sensing probe system guided loading operator in achieving alignment. Loading control room was located underground adjacent to pit. Direct vision of operations was afforded by 5-ft thick water windows and was supplemented by closed-circuit television.

structure in the presence of the ground. The experimental arrangement for measuring the scattered radiation along the ASTR centerline is shown in Fig. 8. Measurements of crew shield penetration were also made. Comparisons of these data taken 12.5 ft above the ground with flight data and with data taken on the towers served to develop a good understanding of ground effects.

**Flight Experiments** — Each of the 17 flight experiments represented a major achievement in coordination. Three airplanes — the NTA, a B-50 escort, and a C-119 rescue airplane — the ASTR and its systems, including 20 channels of nuclear instrumentation, had to be in operation simultaneously.

The B-50 escort had two functions in addition to actually participating in the radiation measurements. It carried observers who scanned the engines and aft portions of the NTA for signs of malfunctions, and parachutists who could be dropped to assist in crew survival in case of an NTA crash or forced landing. The C-119 carried additional parachutists to assess and control radiation hazards in case the ASTR was jettisoned.

During the 48-hr preparation for flight, the NTA was towed to the exclusion area where the ASTR was stored in its underground loading pit. Once the airplane was positioned over the pit, loading operations were controlled remotely from the underground room.

After arrival at the operations area, the reactor core was filled with water and the reactor started up. When the desired operating conditions and power level were achieved, the recording of data began. Measurements were made at altitudes ranging up to 37,000 ft.

**Tower Experiments** — A series of experiments performed with the ASTR and NTA systems at the Oak Ridge National Laboratory Tower Shielding Facility (TSF) concluded the experimental program in 1958. Prior to the tower experiments, measurements had been made in flight (with structure but no ground), with structure and ground, and with ground but no structure. The final experiments were with neither present, since the system could be raised high enough to reduce the ground effects to a negligible level, so that air effects alone could be studied. The ASTR and associated equipment are shown suspended from the towers in Fig. 9.

The measurements at the tower duplicated the major ones made previously on the ground and in flight. The ASTR source terms were re-evaluated, measurements were made in the shielded crew compartment and in the test cylinder, and data were taken at other positions corresponding to those aboard the NTA.

## Results

These experiments took three years. During this period, an intensive parallel effort was made to develop reliable theoretical methods for predicting the performance of aircraft shield systems. Theoretical methods can be validated only by comparing results with experimental data. Thus, the vast amount of data obtained under various conditions with the NTA-ASTR system, in addition to its intrinsic value,

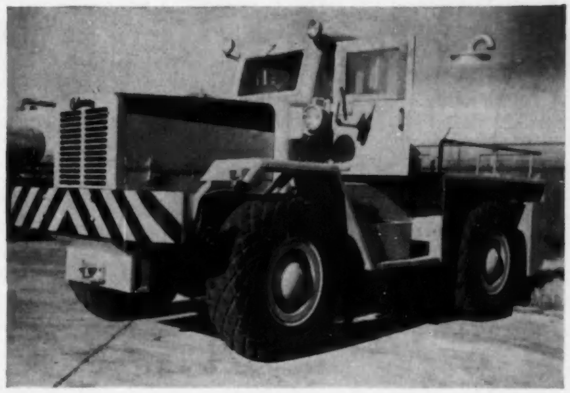

Fig. 5 — NTA sometimes required tow service with reactor aboard. To protect tow operator from radiation, a heavy-duty tow vehicle was equipped with shielded cab and remote control coupling for tow bar. Steel walls 2½ in. thick and lead-glass windows were used to shield cab.

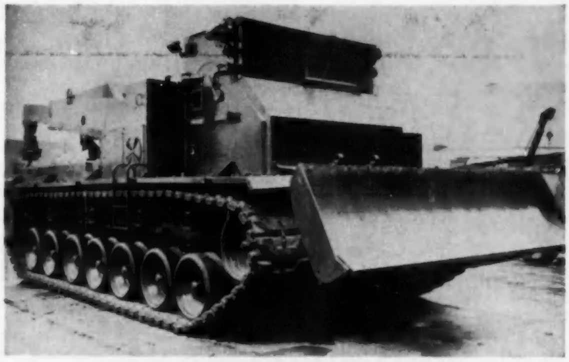

Fig. 6 — Possibility of NTA crash during takeoff or landing with ASTR aboard made it necessary to provide shielded vehicle that could move into crash site rapidly, recover reactor, and dispose of it. T-51 tank recovery unit was modified by adding two-man cab and special salvage equipment, as shown. Cab of this 75-ton vehicle was equipped with 6-in.-thick steel walls and lead-glass windows.

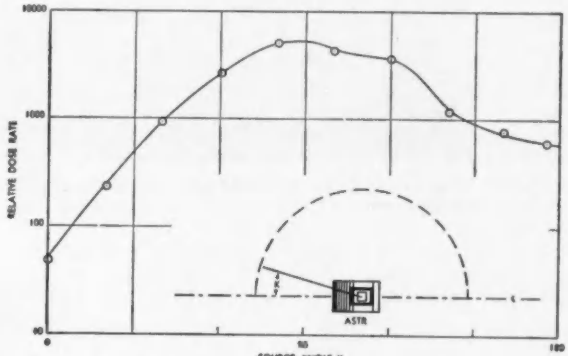


Fig. 7 — Source term measurement. Radiation intensity as function of angle is called "source term" of shielded reactor.

# Nuclear Aircraft

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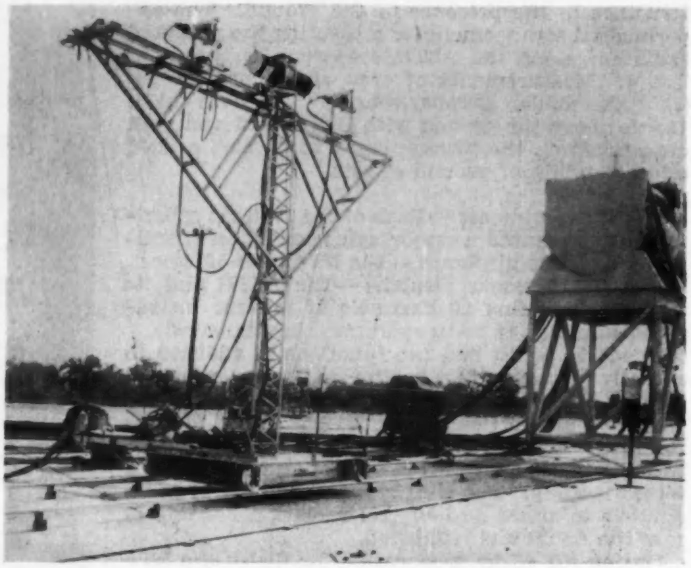

Fig. 8 — ASTR and detector dolly used for measuring scattered radiation along ASTR centerline.

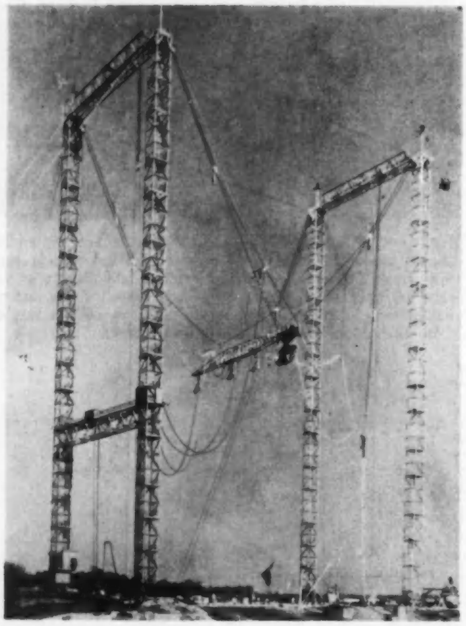

Fig. 9 — ASTR and associated equipment shown suspended from towers.

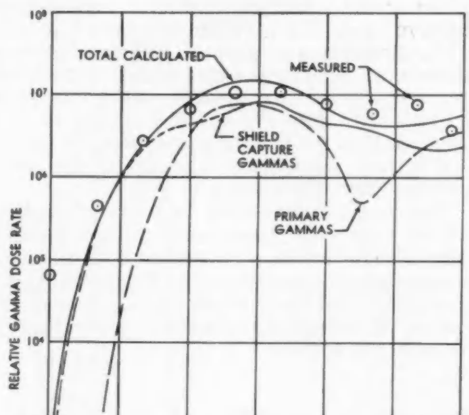


Fig. 10 — Representative ASTR source term for gamma rays.

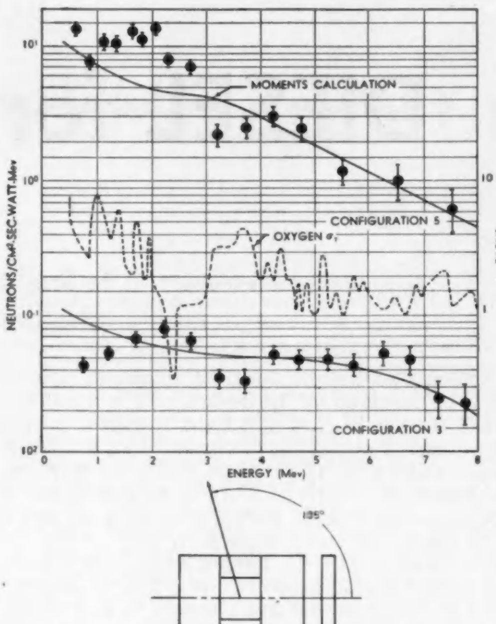


Fig. 11 — Measured and calculated ASTR fast neutron spectra.

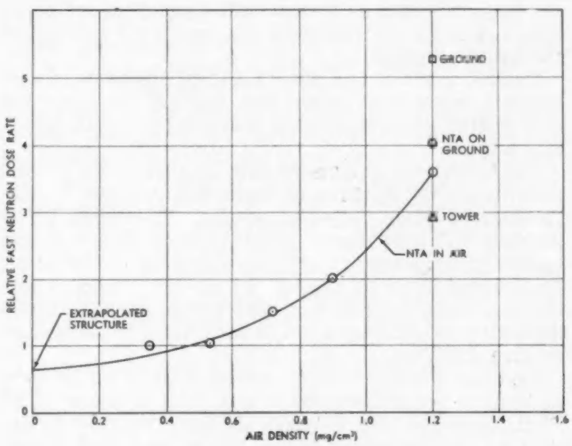


Fig. 12 — Hypothetical data show how data from various experiments fit together.

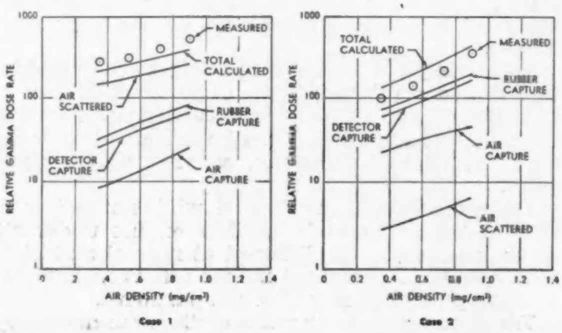


Fig. 13 — Gamma dose rate components (hypothetical data).

has served as a proving ground for advanced methods.

As mentioned earlier, the first step in the assessment of an aircraft shield system is to determine the "source term" or the radiation leakage from the shielded reactor. Fig. 10 shows a representative ASTR source term for gamma rays. The measured data are the total gamma dose rate coming directly from the ASTR shield. The corresponding calculated source term reflects the relative importance of the capture gammas which contribute to the total dose rate from the shield. More than one-half the total comes from neutron capture gammas in the shield itself.

The energy spectrum of the neutrons from the shield is highly dependent upon the amount of water penetrated. Measured and calculated ASTR neutron spectra are shown in Fig. 11. ASTR configuration 5 has several inches less water shielding on the side than configuration 3. The corresponding change in the neutron spectrum is indicated by both the measured and calculated data. Many comparisons such as these have established the accuracy of the methods currently used to predict the leakage of radiation from reactor shields.

Once the intensity and distribution of the radiation leaving the reactor shield have been established, the next step consists of determining the amount of this radiation that reaches a given position of interest, usually in the interior of a shielded crew compartment.

The effect of such factors as aircraft structure and the variation of air density upon the dose rate are studied by comparing data taken under different experimental conditions. A composite picture of the various effects for fast neutrons may be had for a given position and shield arrangement by plotting all the different air, ground, and tower data together as a function of air density. Although actual data cannot be published, the hypothetical data shown in Fig. 12 illustrate how data from various experiments fit together.

Extrapolated to zero air density, the residue represents the effect of pure structure scattering, since this effect should be independent of air density. An extrapolation of the flight data to sea-level air density gives dose rates comparable to those measured on the ground and at the tower. Here, the difference between the extrapolated data and the tower data should represent the net effect of structure scattering and the attenuation by structure of the air-scattered radiation.

Thermal neutron capture in air and in structural materials complicates the problem of predicting gamma dose rates in a crew compartment. The total calculated gamma dose rate is made up of several components. Since the dose rates from individual effects cannot be measured directly, verification of the calculated results is achieved by varying parameters that control the relative importance of the gamma dose rate components. For example, in one case, air scattering may be the largest component while in another, neutron capture gammas may predominate. This behavior is illustrated in Fig. 13.

To Order Paper No. 2R . . .
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# DIESEL for

Based on discussion and paper by **J. S. Bright**

F. Perkins (Canada), Ltd.

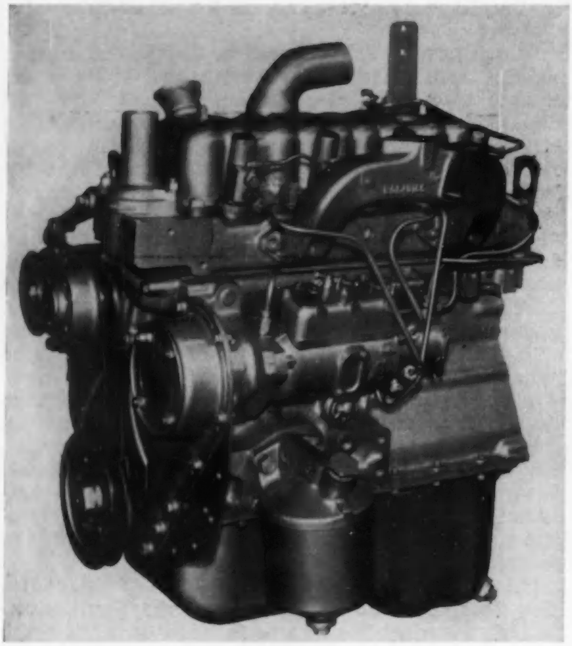

Fig. 1 — The Four 99 — a new diesel designed especially for use in cars and light trucks below 5000-lb gvw.

OLD concepts of weight and low rotational speeds had to be modified by the designers of a diesel engine built for use in cars and light trucks weighing 5000 lb or less. Dubbed the "Four 99," this relatively new powerplant (Fig. 1) develops 43 bhp at 4000 rpm with a maximum torque of 73-ft-lb at 2200 rpm. It is a 4-cyl, in-line engine with a bore of 3 in. and a stroke of 3.5 in. (99 cu in. capacity).

Reduction in inertia of moving parts and a combustion system giving flexibility as nearly as possible that of a gasoline engine was the aim of F. Perkins, Ltd. engineers in developing this design. The dry weight of the bare engine (less flywheel housing, and starter-motor) is only 320 lb. This permits a typical installation to be carried out with a weight penalty as compared with a corresponding gasoline engine of only 100–150 lb — including allowance for the larger batteries necessary.

Examination of the design and of commercial operating experience with this engine indicates its application relationships to a typical 91 cu in. gasoline engine.

Operated in a Baltimore, Md., taxi fleet on an experimental basis, three of these engines saw 20,000, 70,000, and 80,000 miles of service. They gave 22 to 24 mpg, the operator of the taxi fleet says. In the Baltimore experiment, the engines were operated on No. 1 diesel oil of 40 cetane. In earlier Canadian operation, other Four 99 engines were operated without difficulty on standard No. 2 oil found in Canadian service stations.

The designers recommend that SAE 30 oil be used at temperatures above 80 F, and SAE 20 below 80 F. Recommended also is removal, cleaning, and resetting of the injectors every 10,000 to 20,000 miles. This can be accomplished, it is said, with no more difficulty than a spark-plug change. The pintle nozzle in the Four 99 has an advantage over the nozzles used in larger engines built by the same producers.

Since complete conversion packages are available, **installation requirements** are of particular interest. Installations have already been carried out in a wide range of typical cars and small commercial vehicles, both British and European, without serious difficulty.

**The noise level** of the Four 99, while not as low as that of the comparable gasoline engine under all conditions, is not far different at normal and high road speeds . . . provided proper attention is given to soundproofing the engine compartment.

**Vibration** — normally worse in diesels under idling conditions — can be offset by suitable engine mount-

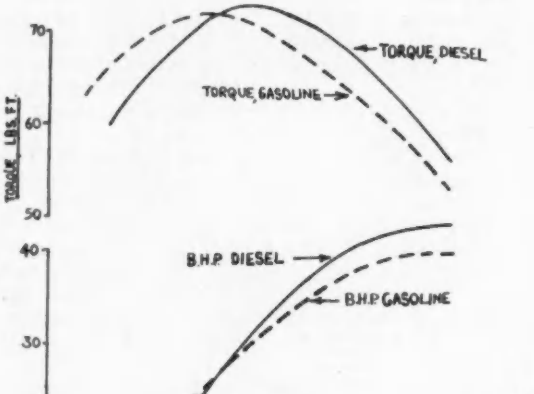


Fig. 2 — Comparison of Four 99 diesel output with that of a typical gasoline engine of same maximum torque.

# VEHICLES under 5000 lb

ings. The Four 99 is little, if any, different from the gasoline counterpart as regards vibration at all road speeds.

**Starts can be made at temperatures below 0 F** with the Four 99 with no aids other than the heating unit situated in the induction manifold with which all engines are fitted. It operates by a switch, which can be combined with the starter switch.

Designers had no trouble achieving required performance as regards combustion smoke in city operation.

**Getting rid of white smoke** while cold starting, however, did pose difficulties. To solve them, a special auto advance device was developed for the fuel pump. This device is sensitive to engine load as well as to engine speed, so the injection timing is advanced as the engine load is reduced.

A comparison of the Four 99 output with that of a typical gasoline engine of the same maximum torque (shown in Fig. 2) indicates that no great difference is to be expected.

**Fuel consumption tests** were carried out on a wide range of cars and light trucks under widely different operating conditions.

On one endurance test, a light van of about 3900-lb gvw (converted to take the Four 99 engine) completed more than 100,000 miles, partly on the road, but chiefly on the MIRA proving ground at a maintained speed of 56 mph. Fuel consumption at 30 mph at the commencement of the test was 36.6 mpg . . . and at the end, 36.4 mpg.

In another test with a Bedford C.A. half-ton van, the vehicle with a Four 99 engine gave 31.6 mpg when operated over a route which included 115 vehicle starts per day. When a gasoline engine was used on the same application, fuel consumption was 12.5 mpg.

The Royal Automobile Club of Great Britain conducted official tests on a Vauxhall Velox car fitted with a Four 99 powerplant over a distance of 218 miles. The route consisted of fairly narrow, twisting, and hilly roads with a number of small towns, and city driving involved. The fuel consumption officially recorded for the distance was 47.2 mpg at an average speed of approximately 34 mph.

As regards maintenance, the Four 99 is too new to have built up experience over a large number of engines. In the Baltimore Taxi Fleet experiment, the engines were finally taken out of service because of difficulty in obtaining parts promptly. But a number of experimental Four 99's have achieved 100,000 miles without overhaul and are continuing satisfactorily.

Front and side cross-section views of this Four 99 diesel are shown in Figs. 3 and 4.

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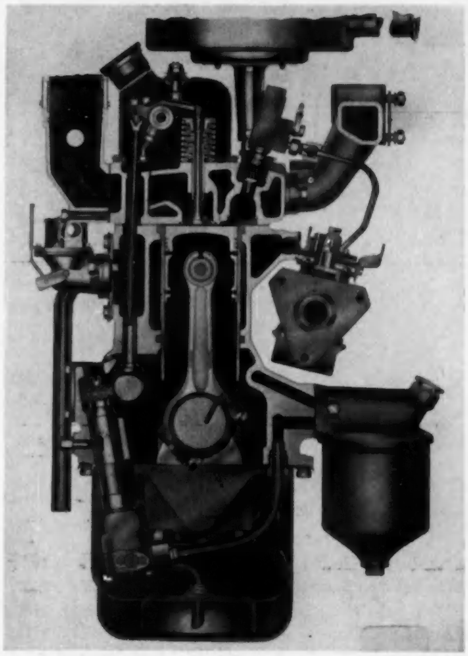

Fig. 3 — Front cross-section view of Four 99 diesel designed for vehicles below 5000-lb gvw.

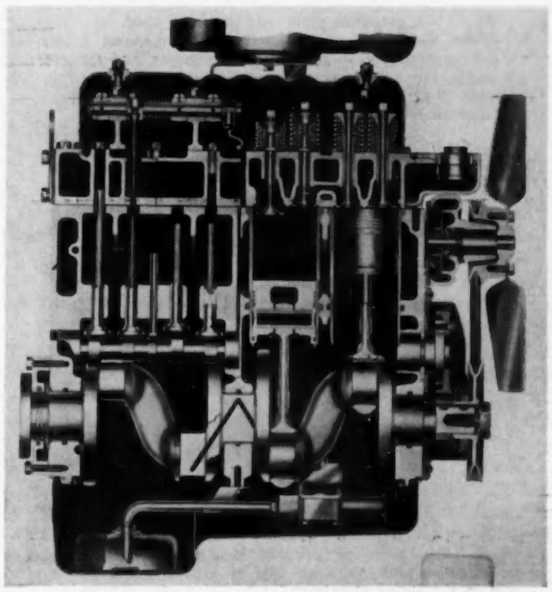

Fig. 4 — Side cross-section view of Four 99 diesel.

# Studebaker's LARK

Based on paper by

**E. J. Hardig**

Studebaker-Packard Corp.

THE Lark design was developed by a small group of key people working together toward a well-defined objective. Styling, engineering, purchasing, production, and sales were all represented in this joint effort. This is in sharp contrast to the customary practice of having individual groups work separately with a design already set by the stylists.

The objective set was a car with inside dimensions adequate for six full-sized passengers. Overall length was to be reduced by elimination of nonfunctional front and rear overhang and by shortening the wheelbase to an optimum dimension for good ride characteristics. This was accomplished with a wheelbase of 108½ in. — 8 in. less than the previous model, and with a weight saving of 250 lb.

Fig. 1 — One-piece panel running full width of Lark carries headlights, parking and directional signal lights, combined with ventilating air intake grilles, and radiator grille. Front sheet metal assembly is made up of a minimum of parts which are bolted together, making replacement easy in case of damage.

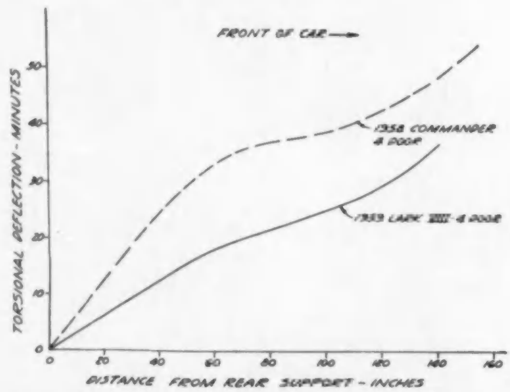


Fig. 2 — Comparison of Lark with 1958 model shows reduction in deflection under torsional load of 1200 ft-lb, indicative of gain in rigidity of structure.

## Quality with Economy

Some real dividends in product quality were gained by reducing the number of parts in the body and sheet-metal structure. Fewer manufacturing tolerances and variations mean fewer misfits. Fewer joints mean fewer squeaks and rattles, and assure consistent structural strength in the assembly and in service.

The front sheet-metal assembly, for example, is made up of a minimum number of parts which are bolted together (Fig. 1). Any one of these can easily be removed and replaced in case of damage. The grille is a one-piece perforated stamping instead of a costly assembly of many individual pieces. Its third-dimensional effect is created by the surface formation of the metal. The bright grille molding of the higher-priced model is retained by the same fastenings as the grille.

Rear fenders are also bolted on for easy replacement. Shortening the rear end overhang while maintaining trunk height made the rear panel substantially a vertical surface. Rather than incorporate this area in the deck lid, a full-width rear panel was designed as an integral structural part to gain

| Specifications Dimensions (in inches) | |
|---|---|
| Wheelbase | 108.5 |
| Overall Length | 175 |
| Overall Width | 71⅜ |
| Overall Height (Loaded) | 57.5 |
| Hip Room: Front — Rear | 59.5-59 |
| Leg Room: Front — Rear | 36-35 |
| Turning Diameter (Wall-to-Wall) | 40 ft |


| Engines | L-Head 6 | OHV-V-8 |
|---|---|---|
| Bore and Stroke | 3.0 x 4.0 | 3.56 x 3.25 |
| Piston Displacement | 169.6 | 259.2 |
| Compression Ratio | 8.3/1 | 8.8/1 |

body rigidity. This structural strength is augmented by a redesigned ladder-type box section frame with greater torsional and bending strength to get the solid feel and quietness usually associated with a much heavier car.

The torsional characteristics of the 1958 four-door sedan and its Lark counterpart are compared in Fig. 2. The data were obtained by supporting the car rigidly at the rear and on a knife edge at the center of the front cross-member, applying a torsional load of 1200 ft-lb at the front, and measuring the resultant angular twist at various stations along the length of the car. In addition to a significant reduction in deflection at all stations, the Lark curve more nearly approaches a straight line, indicating a more uniform deflection throughout the length of the structure, thereby minimizing stress concentrations.

## Variable-Rate Front Springs

Excellent ride characteristics were gained by using variable-rate front coil springs and asymmetrical rear leaf springs. With carefully developed shock absorber control, these produced an ideal balance between front and rear suspensions. This result contravenes the common belief that a better ride can be gained only by increasing weight and lengthening wheelbase — a belief which is true if no consideration is given to redesigning the suspension.

The nominal rate of the Lark VIII front spring is 180 lb per in. up to curb load, as shown in Fig. 3. When a wheel jounce depresses the spring, the upper coils close progressively, causing the rate to increase to a maximum of 375 lb per in. The nominal spring rate produces a wheel rate of 68 lb per in. and a sprung mass natural frequency of 55 cpm. Following the straight line continuation of the 180-lb per in. rate, as shown on the chart, reveals that a constant spring rate would bottom at 1990 lb, compared with 2355 lb for the variable rate spring. If a constant rate spring were designed to reach a 2355-lb bottoming load and still maintain the same curb height, its rate would be 278 lb per in. So here we have our cake and eat it too — we get a very low nominal rate for a soft ride and a high bottoming load to prevent frequent crash-through of the suspension.

## Comfort for the Driver

The interrelation of the ride motions produced by front and rear suspensions greatly influences ride characteristics. Two major motions are involved: a pitching about an axis inside the wheelbase and a bouncing about an axis outside the wheelbase. The location of these axes of oscillation and the frequencies about the axes determine the basic ride. In the Lark VIII, the pitch and bounce axes of oscillations are closer to the adjacent wheel centers than in the 1958 Commander (Fig. 4). The pitch frequency has been increased slightly to 89 cpm and the bounce frequency lowered to 61 cpm.

What counts in making these changes is the effect on the driver. His head is subjected to inertial forces about the pitch and bounce centers since it is located some distance above the plane of the axes of oscillation. If the velocities produced by these forces are low and the motions of pitch and bounce

# Studebaker's LARK

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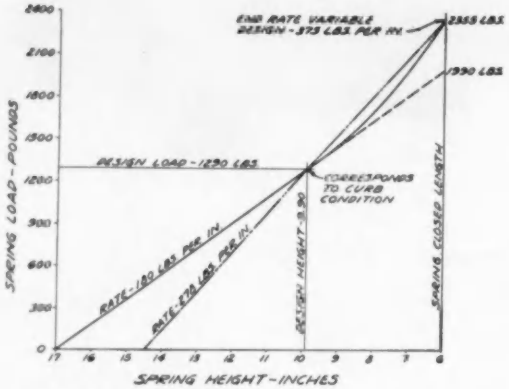


Fig. 3 — Use of variable-rate front coil springs gives very low nominal rate for soft ride and high bottoming load to avert crash-through of suspension. To obtain similar bottoming load with constant-rate spring would require having higher nominal spring rate.

produce phase opposition shortly after a disturbance, the rider can be comfortable. Phase opposition is obtained for the Lark VIII within 1.7 sec after a disturbance, whereas the 1958 Commander does not attain phase opposition within any reasonable period. This is shown in Fig. 5.

Since the Lark suspension produces lower resultant velocities than the 1958 model, the passengers can be moved through greater amplitudes to get a soft ride. Consequently, a shock absorber control was established to provide larger amplitudes. Phase opposition has flattened the ride without the necessity for excessive shock absorber control, hence the shock absorber is used as it was intended — to control the amplitude of motion.

## Modifications in the 6-Cyl Engine

Increasing the compression ratio from 7.5/1 to 8.3/1, coupled with a reduction in engine displacement, made necessary use of a completely new combustion chamber shape with a volume 11 cc (or nearly 20%) smaller than in 1958. The new design (Fig. 6), under study for several years, produced more power with less fuel but it had the undesirable trait of aggravating a front main bearing noise, commonly referred to as bearing bump. The chamber design was ideally suited, provided a solution could be found to the bump problem.

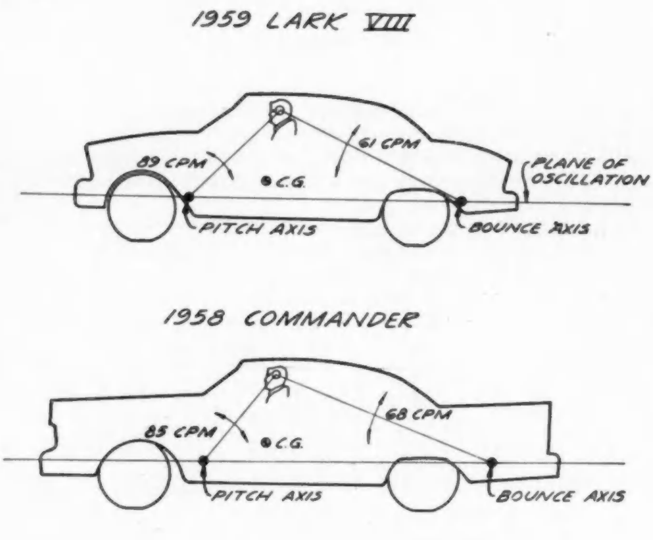


Fig. 4 — Pitch and bounce axes of oscillations are closer to adjacent wheel centers on Lark. If pitch and bounce velocities are low and the two motions produce phase opposition shortly after disturbance, ride is comfortable.

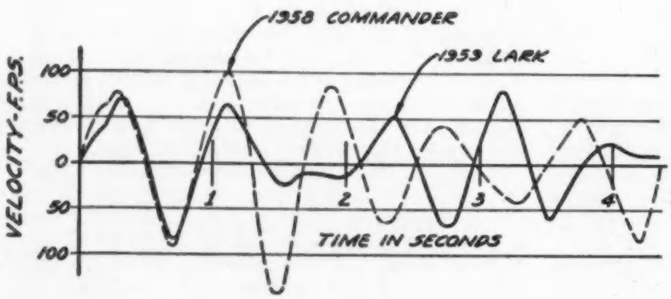


Fig. 5 — Resultant of pitch and bounce velocities with Lark VIII and 1958 Commander. This is the effect at driver's head with vehicle speed of 30 mph. Phase opposition for Lark is obtained within 1.7 sec after a disturbance, much later for Commander.

A solution was reached with less difficulty than anticipated. The shorter stroke of the new engine permitted a greater journal overlap in the crankshaft, which resulted in a much more rigid crank. This additional rigidity, coupled with a reduction of the front main bearing clearance to maximum of 0.002 in., reduced the bump to a point satisfactory to even our most discriminating engineers. Moreover, the crankshaft overlap made possible a manufacturing economy. The oil passages from main journals to connecting rod journals were now straight and could be drilled in one operation rather than two, as heretofore (Fig. 7).

## Evolution of Piston Design

The design of the Lark piston, compared with its 1958 predecessor, is shown in Fig. 8. It was reached after experimentation with variations in length, high and low ring position, single translot and T-slot skirts. An interesting problem was encountered in developing the skirt design. It was believed the single translot design would be most desirable because of the higher compression ratio. But early tests indicated a degree of oil control below that expected or desired. A set of pistons was then converted to T-slot design and improvement followed. Subsequent tests proved oil control to be well within acceptable limits and better than with the 1958 engines.

## Debugging the Carburetor

Road tests carried on during development of the new carburetor for the Lark VI disclosed an unsteadiness in the engine at speeds between 20 and 25 mph, under light accelerating conditions. Investigation revealed that the air-fuel mixture, on entering the manifold, was deflected by the carburetor throttle valve to the inner wall of the manifold riser to cause poor fuel distribution. The insertion of a flared orifice between the carburetor and manifold acted as a deflector and corrected the condition. Furthermore, it produced an improvement in fuel economy, cold starting, and operation during warmup.

## Performance Goes Up

When the power of the Lark VI engine is compared with that of its 1958 counterpart, there is

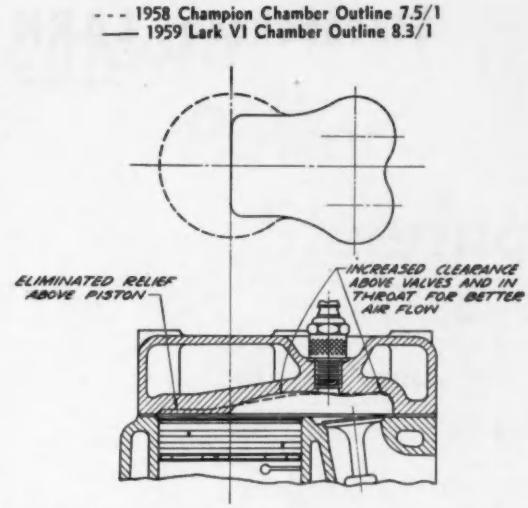


Fig. 6 — Combustion-chamber design represents radical change necessitated by increase in compression ratio and reduction in displacement.

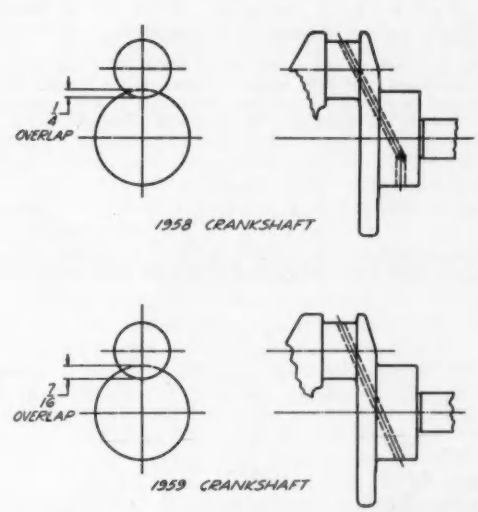


Fig. 7 — Crankshaft has greater journal overlap, giving more rigidity. Oil passages can now be drilled in single operation.

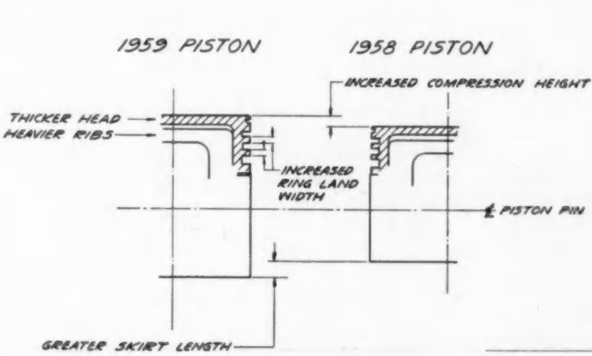


Fig. 8 — Thicker head section and heavier supporting ribs improve piston head stiffness. Piston is longer in compression height and skirt length to give better stability. Lowered ring position and increased ring land width add to ring life.

# Studebaker's LARK

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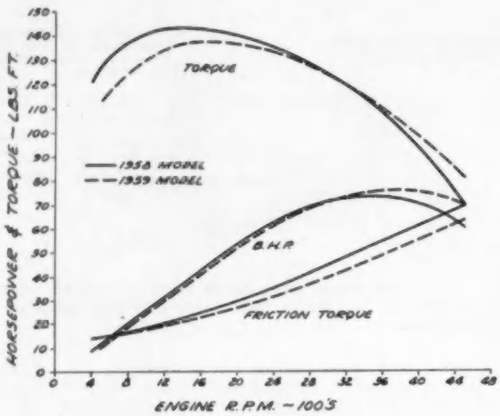


Fig. 9 — Lark VI shows less torque below 3200 rpm, but an improvement over 1958 model at higher engine speeds. Reduction in engine friction losses means better fuel economy. This study was made with all accessories installed.

shown to be some loss in torque below 3200 rpm, but more power at higher speeds (Fig. 9). This loss is not of the magnitude that would normally be expected from the difference in piston displacement. The reduction in friction torque is very significant from the standpoint of fuel mileage.

Except for a higher compression ratio, and a new inlet manifold, carburetor, and air silencer, the Lark VIII engine is substantially the 259 cu in. engine of the 1958 Studebaker models. The compression ratio was raised to 8.8/1 by changing the thickness of the cylinder head gasket. Combinations of a new embossed steel gasket or the former steel-asbestos gasket with two basic cylinder heads makes possible four ratios, ranging from 7/1 to 8.8/1. The lower ratios are intended for cars exported to markets where only low-grade fuel is available.

The improved Lark VI engine, the lower vehicle weight, and the carefully selected axle ratios combine to give better gasoline mileage and acceleration than found in the 1958 Scotsman (Fig. 10). The Lark VIII also shows an improvement over the 1958 Commander. As in the case of the Lark VI, gasoline mileage shows the greatest gain at a speed of 30 mph in overdrive, with a tapering off as speed increases (Fig. 11). Proving ground tests showed a 2 mpg improvement in the Lark VI, and more than 3 mpg in the Lark VIII, over corresponding 1958 models.

Although vehicle weights are lower, brake sizes remain unchanged. Accordingly, the car weight per square inch of brake lining has dropped from 20.3 to 18.7 lb on the Lark VI and from 19.3 to 17.8 lb on

## Table 1 — Steering Comparison between Lark Models and Their 1958 Counterparts

| | Front End Weight, lb | Tire Size | Gear Ratio L | Gear Ratio - C | Gear Ratio - R | Overall Ratio L | Overall Ratio - C | Overall Ratio - R | Wheel Turns | Average Parking Effort Rim Pull, lb |
|---|---|---|---|---|---|---|---|---|---|---|
| 1959 Lark VIII 4-Door Sedan | 1800 | 6.40 × 15 | 20 | 22 | 20 | 27.5 | 24.5 | 27.5 | 4½ | 25.6 |
| 1958 Commander 4-Door Sedan | 1930 | 7.50 × 14 | 20 | 22 | 20 | 27.5 | 24.5 | 27.5 | 4½ | 32.8 |
| 1959 Lark VI 4-Door Sedan | 1480 | 5.90 × 15 | 15.4 | 13.5 | 15.4 | 25 | 19.5 | 25 | 5 | 29 |
| 1958 Champion 4-Door Sedan | 1640 | 6.40 × 15 | 18.5 | 16.5 | 18.5 | 29.5 | 21.5 | 29.5 | 5¼ | 32.6 |

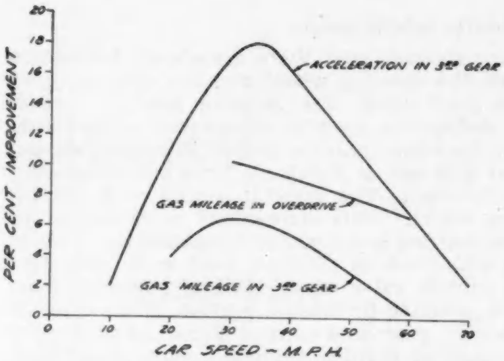


Fig. 10 — Per cent performance improvement of 1959 Lark VI over 1958 Scotsman 6. Acceleration has improved over entire speed range with maximum gain at 35 mph.

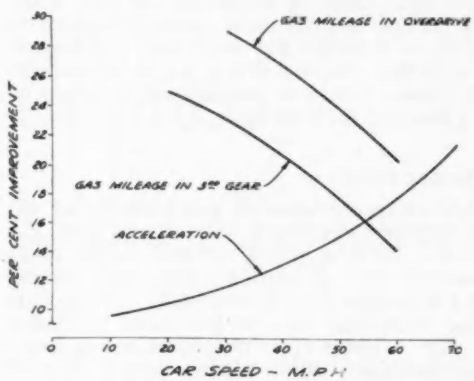


Fig. 11 — Per cent performance improvement of 1959 Lark VIII over 1958 Commander 8. Comparison of acceleration characteristics shows percentage gain to be nearly proportional to car speed. Substantial gain in fuel economy is also evident.

the VIII. The average for 10 of the 1959 lower-priced car models is 19.8 lb.

## Improvement in Steering

Reduction in weight, the shorter wheelbase, and smaller tires all contribute to better steering and handling. The Lark VIII retains the variable-ratio, roller-stud steering gear used in 1958, but parking effort has been reduced 22%. This is shown in Table 1. The Champion steering gear was considered for the VI, but it proved too slow in response, and its recovery from turns was poor because of the lower vehicle weight. For this reason a new variable-ratio, fixed-stud gear was adopted. Here, parking effort was reduced 11%.

**To Order Paper No. S152 . . .**
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# Lincoln Power Steering

## *. . . features torque bar as reaction member to give better steering feel.*

Based on paper by

**R. A. Pittman and W. A. Van Wicklin**

Ford Motor Co.

FIRST to abandon hydraulic reaction in power steering, Lincoln is using a torsion bar reaction to gain a natural steering feel and low parking effort with good recovery. This design affords a variable torque such that manual effort decreases as the output torque increases.

The steering gear is an integral assembly comprising a gear reduction unit, power cylinder, and control valve within a single housing. A recirculating ball-nut and sector-type gear reduction is used, the velocity ratio of the gearing being 17/1. Both the rack teeth on the ball-nut and the sector teeth on the shaft have constant pitch. A high point on mesh is obtained by machining the sector gear slightly eccentric to the shaft bearings. As the sector shaft rotates off center position, a small amount of backlash is introduced to prevent the occurrence of secondary high points off center, caused by tooth spacing or profile errors.

A second sector gear on the sector shaft meshes with the rack teeth on the piston rod extension. Two oil passages through the housing connect the control valve with the power cylinder.

### design of control valve

The control valve is concentric around an upper extension of the worm shaft, as shown in Fig. 1. A torsion bar within the worm shaft is pinned to the input shaft at its upper end and splined to the worm shaft at the lower end. The input shaft is threaded to the valve actuator. Splines between the valve actuator and worm shaft extension rotate the actuator with the worm. Relative rotation between the input shaft and worm moves the actuator up or down the input shaft threads, carrying the valve spool with it to direct hydraulic fluid to the proper

# Lincoln Power Steering

. . . **continued**

side of the power cylinder. Power assistance is provided whenever there is relative rotation between the input shaft and the worm.

The control valve is open centered for a constant rate of supply flow. There is no hydraulic reaction force on it, consequently only very light forces are carried by the actuator threads and splines. The purpose of the actuator is to translate the relative angular displacement between the input and worm shafts into a corresponding axial displacement.

## significance of the torsion bar

A torsion bar is used as a reaction member to produce a fine natural steering feel. The steering wheel input torque is transmitted to the torsion bar with very few losses, consequently steering effort is nearly equal to the spring rate and angular rotation of the torsion bar.

Another function of the torsion bar is to transmit recovery torque to return the steering wheel to center position. Since the frictional load is very small, complete recovery is achieved without the use of preloaded centering.

The torsion bar also serves for valve centering adjustment. At the lower end of the torsion bar is an adjusting screw, which is accessible through a plug hole opening in the housing. As the adjusting screw is turned, the torsion bar is moved axially, carrying the input shaft, actuator, and valve spool. The centering adjustment locates the control valve in hydraulic neutral position. Stops between the input shaft and worm extension limit the twist of the torsion bar. When steering without power, the high manual input torque is transmitted through these stops.

## effort-error relationship

In any steering gear there are elastic deflections between the steering wheel and the steering gear output shaft when the steering gear is loaded. These deflections may be considered a positional error in that less than the desired change in output angular position is obtained for a given steering wheel rotation. The error increases with greater steering effort. This error-effort relationship for Lincoln steering and hydraulic reaction is shown in Fig. 2 with manual steering used as a base line.

The control valve of all integral power steering gears is actuated by using a portion of the error in the steering gear as a control signal. Added error is provided to furnish sufficient valve movement. In the Lincoln unit, the torsion bar permits the additional error required for valve actuation. The torsion bar twist is added to the deflection of a manual steering gear. The resultant curve has the same natural shape as that of a manual steering gear. There are no discontinuities or abrupt changes in slope. At 75 in.-lb input, the stops limit the torsion bar twist at 10 deg. Beyond this point, greater steering effort causes the same increase in error to be found in a manual steering gear.

## variable torque ratio

When the characteristics of the torsion bar reaction spring are combined with a properly designed control valve to give a variable torque ratio, a very natural feel is gained. For light output torques a low torque ratio is provided. As the output torque increases, the torque ratio increases linearly. The variable ratio characteristic is without discontinuities. High torque ratios of over 200/1 give easy steering effort for the heaviest parking loads.

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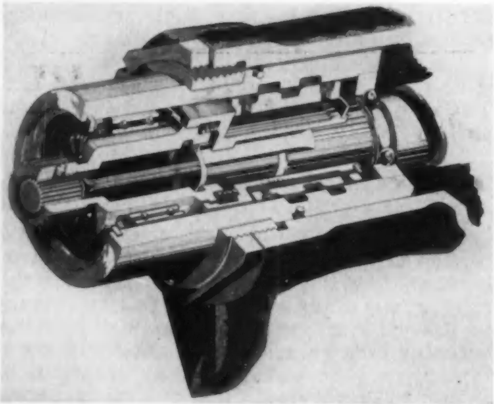


Fig. 1 — Control valve of Lincoln power steering is concentric around an upper extension of worm shaft.

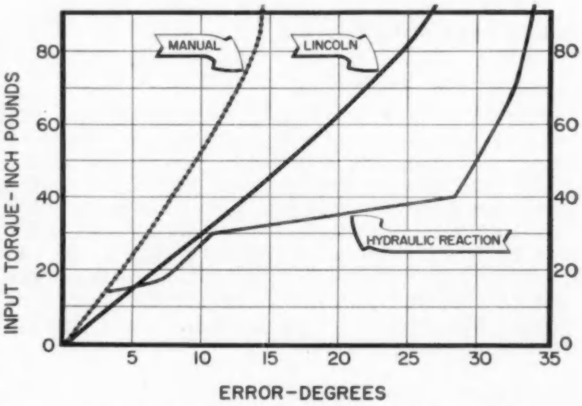
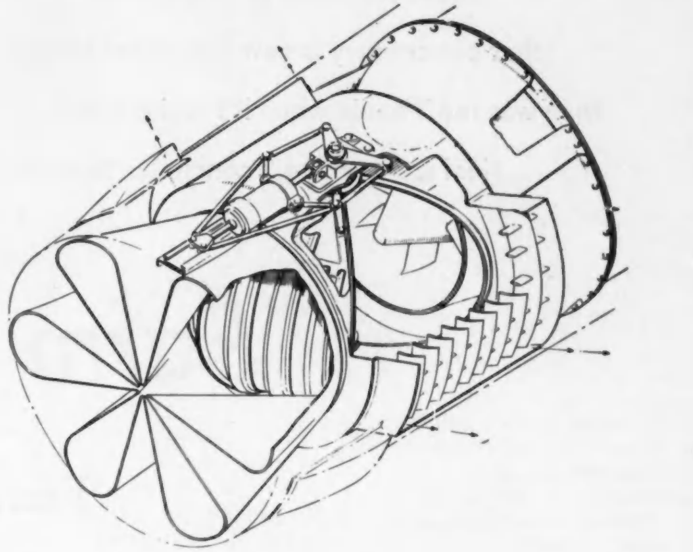



Fig. 2 — Comparison of effort-error relationship found in Lincoln power steering and systems with hydraulic reaction. Lincoln system more nearly approximates manual steering.

# Thrust Reverser Ahead of Silencer



## makes a compact and rugged design.

Based on paper by

**K. I. C. Vincent**

Rolls-Royce Ltd.

PUTTING the thrust reverser in front of the silencer is the solution chosen for the Comet III and the Boeing 707. This design has been backed up with thousands of hours of running time and reversal cycles.

The forward reverser location was picked because it keeps the steady and fluctuating loads down and produces a compact unit. To keep the moving units simple and to a minimum, a fixed outlet type was selected. In this case doors are used to cover the reverser outlet ducts in the forward thrust condition. For reverser thrust the doors swivel to block the main gas duct and at the same time expose the reverser outlet.

During tests by Rolls-Royce a series of design and construction problems was solved. As a result a reverser was produced that gives 56% reverse thrust at 95% rpm.

Early in the testing it was found that the exit area of the reverser has to be at least one-third larger than the main gas duct. Otherwise excessive throttling of the engine exhaust produces limiting tail pipe temperatures at low engine rpm. Also, the design of the vanes must be checked by flow studies for even a large exhaust area will not make up for poor aerodynamics.

Closing off the outside of the reverser with a door appeared to be necessary to keep the drag down during normal flight. A series of tests showed this refinement unnecessary. By checking the effect of the shape of the outlet, the immersion of the reverser ducts relative to the skin, and the skin contour, a no-door arrangement was found that had only one-eighth the drag increase of a plain hole.

Roller bearings were selected for the eyelid of the reverser's clamshell. These bearings are unlubricated and operate in high ambient temperatures. Plain bearings had a better appearance after 1000 hr of testing but were rejected because their high frictional resistance would have meant a heavier operating mechanism.

Time and motion studies of the pilot's actions were used to design a fast operating yet safe actuating system. Emphasis was placed on this control function because flight tests showed a 1-sec reduction in time from touchdown to full reverse thrust was equivalent to at 31% increase in reverse thrust.

**To Order Paper No. 85C . . .**
. . . on which this article is based, turn to page 6.

"There are those of us who feel that our country is now in greater danger than was the Titanic when it received its final ice-warning," concludes this article on:

# Russian Farm Machinery

## Today and . . . Tomorrow

**By Wayne H. Worthington,**
director of research, Deere Mfg. Co.

## Today's Soviet Tractors Are Heavy for Their Power

MODERN Soviet agriculture started in 1929 with the establishment of the state or factory type farms. Concurrently, the All Union Institute for the Mechanization of State Farms was founded to develop the machinery and methods necessary for mechanization.

Millions had perished in the famines which had swept great areas since the start of the Revolution, others had died in the civil war which followed. Horses and livestock had been decimated and the economy was at an all time low. The next ten year period was spent in adapting foreign built tractors and implements to Soviet agriculture, training operators and building up adequate service facilities with competent maintenance personnel.

Tractor and implement factories came into production using American Tractors as prototypes. Machinery supply never approached the needs. In 1941 came the agonies of war, and the industrial heart of European Russia was overrun by German panzers. Between the scorched earth policy of the doggedly retreating Russian forces (a fact steadfastly denied wherever we went) and the vengeance of the occupying German armies, the country was a shambles.

Following the war, new tractor factories were built and brought into production at Minsk, Vladimir, Libetz, and Stalingrad. The huge tractor plant at Kharkov, the Combine plant at Rostov-on-Don, were rebuilt from the rubble of destroyed buildings, and smaller implement plants at Kirovagrad, Tagonrog, Odessa and Dniepropetrovsky were built and brought into production.

Designs for tractors were supplied by the State Scientific Tractor Research Institute (NATI) and for implements by the Institute for Farm Machine Design and Testing (both of Moscow) and the Central Construction Bureau of Zaparozhe. As production increased and the technology of application improved, new designs were created and developed.

### Machinery Follows Crop Needs

In a Communist society, the design and development of new farm machinery is determined by crop needs rather than the uncertain prospects for realizing a profit on the part of the manufacturer, as

SAE LOOKS OVERSEAS

A feature of the SAE Overseas Information Advisory Committee


in our capitalistic society.

For instance, much work is being done at the Soviet Institutes and Machine Testing Stations to develop machines for the harvesting of castor beans. Concurrently, plant geneticists are developing bush type strains of castor beans, ranging from three to five feet high, and which drop their leaves as soon as frosted. With a high yield per acre as compared with previous varieties, these new varieties of castor beans are particularly suited to machine harvesting. This mechanical-plant breeding development is proceeding simultaneously, although in 1958, only 125,000 acres of castor beans were grown in the entire USSR. However, present state five year plans call for 1,250,000 acres by 1960.

The new seven-year plan, to be announced in January, can be expected to be even greater. This great expansion in castor bean production, with its mechanical and chemical implications, affords more than one clue to Soviet thinking.

Contrast the parallel development under way in the USA which decidedly is a "which comes first, the hen or the egg" proposition. The yield of present American dwarf castor beans is low. To make matters even worse, the leaves cling tenaciously to the stems after frost, adding immeas-

**THIS SEARCHING ANALYSIS of Russian tractor, farm equipment, and agricultural futures is one of the most important first-hand technical studies ever to come out of Russia in the automotive field.**

**Wayne Worthington, the author, traveled 9000 miles throughout the USSR last Fall. He was the lone "industry" member of a 6-man Scientific and Engineering Team sponsored by the U. S. Department of Agriculture under the Soviet-USA Cultural Exchange Program.**

**Worthington's current appraisal of Russia's rapidly developing farm equipment industry is fortified by first-hand knowledge of Russian agricultural methods over a long period of years. He started his career as an automotive engineer, in fact, by working throughout the vast reaches of pre-revolutionary Russia and Siberia . . . as a field engineer for a pioneer American farm machinery manufacturer. Now he is director of engineering & research, John Deere Waterloo Tractor Works . . . is a past vice-president of SAE, representing Tractor and Farm Machinery engineering, was formerly a member of SAE's Publication Committee, and is a past-president of the Society of Agricultural Engineers.**

**On his trip to the USSR last Fall, his scheduled visits included 3 ministries; 9 scientific and research institutes; 4 of Russia's largest tractor and farm machinery factories; 4 Repair Technical Stations; 3 state farms (Sovkhosi); and 6 collective farms (Kolkhozi) . . . Visited in addition were numerous villages, public schools and cultural centers, where Worthington and other Team members talked freely with hundreds of people on all levels of Russian life.**

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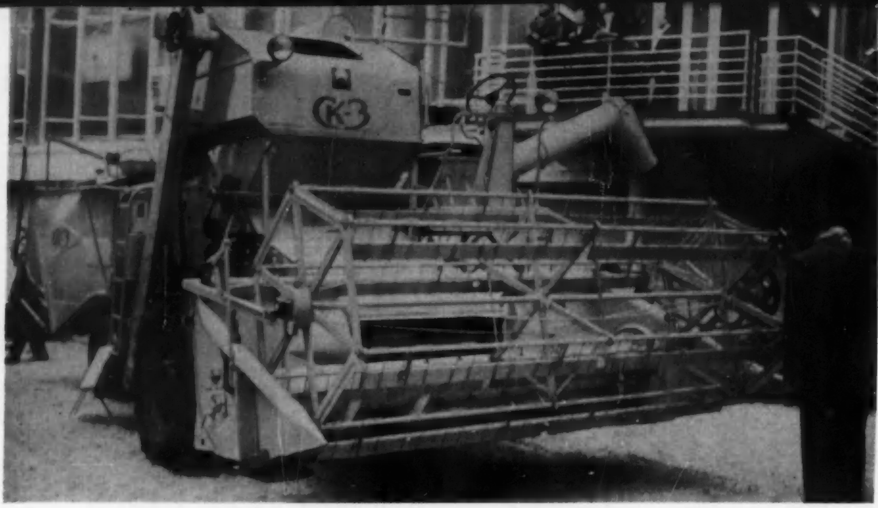


CK-3 Self-Propelled Combine with pick-up.

## Russian Farm Machinery

. . . continued

urably to the difficulties of combine harvesting. With foreign producers supplying the major portion of our limited needs for castor oil, the acreage devoted to the production of castor beans scarcely justifies the heavy development expense in terms of time and money necessary to market an acceptable combine for a strain of castor beans which our plant geneticists have yet to produce. The best that has been done to date within the USA has been an un-coordinated effort to produce a castor bean harvesting attachment for self propelled grain combines.

A "planned economy" differs from ours in many other aspects. For instance, by August of 1958, all orders for tractors and farm machinery for 1959 delivery had been placed and accepted on an allocation basis, up to the limit of available production capacities. What American industrial management wouldn't love such a situation? In other ways, it works ruthlessly and without consideration of the individual. At a meeting with high Soviet Officials in the Ministry of Agriculture, we raised the question of the problems arising from the displacement of farm labor as farm mechanization proceeds. The reply was terse and unequivocal, "That will be no problem for us. We work according to plan. The labor will be used."

### Three Non-Farm Tractors

There are three non-farm types of crawler tractors now in production, viz;

**Model S100 Crawler:**

Closely follows its American prototype, except that a Ricardo type combustion chamber is used for greater fuel economy, and multiple disk dry master and steering clutches are used.

Produced at the rate of 75–100 daily at the Tchelyzbink Tractor Works in the Ural Mountains.

**Model TDT Logging Crawler:**

A distinctive Soviet development, based upon earlier military designs, with large diameter bogie wheels. This tractor is produced at the rate of 20 tractors daily at the Byelaruss Tractor Works at Minsk. It is powered with the 45 hp Byelaruss diesel engine. Whether built elsewhere was not determined.

**Model TDT 60:**

A heavy logging tractor built in a special factory at Petrozavodsk, about 125 miles northeast of Leningrad. We were unable to gather details regarding this unit. Both logging tractors appear to be well integrated, thoroughly developed units, intended for the extreme conditions imposed by logging service.

Six basic models of farm tractors, all with diesel engines, are currently in production, as follows:

**DT54 — 54 hp Crawler:**

This tractor has been in production at Kharkov since 1951, and is also built at Stalingrad and Rubtsovsk.

Daily production rates are as follows:

| | |
|---|---|
| Kharkov | 80 |
| Stalingrad | 110 |
| Rubtsovsk | 40 |
| Total | 230 units |

**"KIROVETZ" KDP-38 — 38 hp Crawler:**

This interesting crawler is built at Lipetz in three different models, as follows:

DT35 — High clearance model.
DTT35 — Conventional low clearance model.
DT40 — Row Crop model with narrow tracks.
Total daily production 55 units.

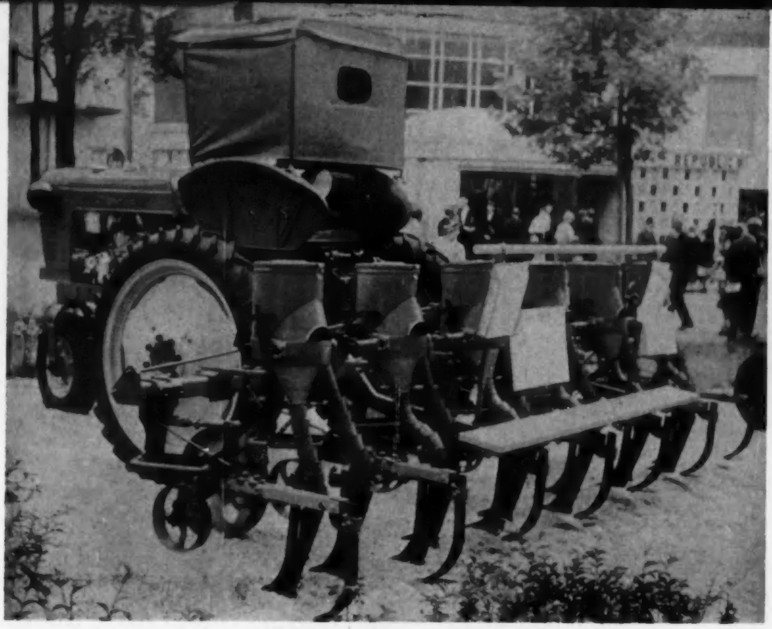
**MT3-5M Wheel Type Row Crop Tractor, 45 hp:**

Currently built in two row crop models, viz:

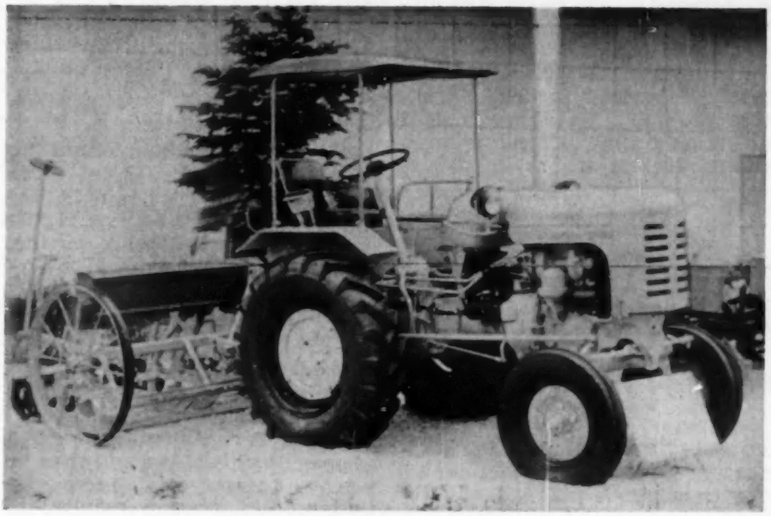
A. Conventional 2 wheel drive adjustable tread type, with high ground clearance. Available with either a conventional adjustable tread wide front axle, or a single front wheel for narrow row crop cultivation.

B. Four wheel drive model, following the conventional European pattern with front wheels having a smaller diameter than the rear wheels.

Current daily production 100 units



12 row drawn Row Crop Drill.



DT-20 Wheel Tractor (Kharkov) with grain drill.

**"VLADIMIRETZ" DT28 — Row Crop Tractor, 28 hp:**

A small 2 row, two cylinder tractor, currently built at the Vladimir Tractor Works in four wheel and tricycle models.

Current daily production 60 units

**DT20 — Row Crop Tractor, 16-20 hp:**

A small single cylinder 4-wheel-type row crop tractor, built in a separate division of the Kharkov Tractor Works.

Current daily production 80 units

(At the time of our visit, 25 units a day were being boxed for export shipment to India).

**ABCШ — 16 Self Propelled Chassis:**

A small specialized implement carrier type of tractor, built by the Kharkov Tractor Assembly Works. It closely follows the general design originated six years ago by Heinrich Lanz, A. G., of Mannheim, West Germany. It is powered with the same single cylinder diesel engine built at the Kharkov Tractor Works for the DT20 Row Crop Tractor.

Current daily production 20 units

This gives a total daily production of 545 tractors, of which 285 (52%) are crawlers and 260 (48%) wheel tractors.

In general, all tractors are heavy for their power. The average shipping weight, per engine hp, including hitch and hydraulic lift, but without wheel weights are as follows:

| | |
|---|---|
| Crawlers | 237 pounds |
| Wheel Tractors | 170 pounds |

### Reasons for Weight

Although factory engineers did not discuss the matter in detail, there are a number of reasons for this heavy specific weight.

1. At the time the tractors were designed, materials were inferior to those available today.
2. Engineers were taking no chances on a design being too light. Structural failure of an experimental machine entailed heavy penalties.
3. It is traditional with Russian engineers that machinery be designed with a long service life, so as to wear out long after it becomes obsolete.

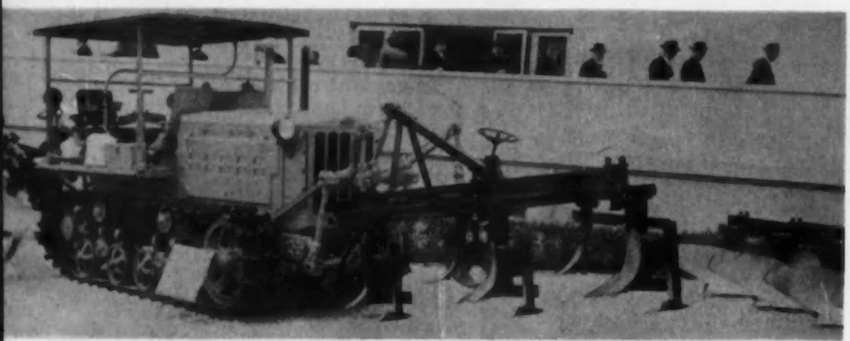
Published values of specific fuel consumption appear to be high, especially when compared with the best American farm tractors.

Russian engineers appeared to be able and well qualified. Unfortunately, most factory engineers lack the independence of their American counterparts. This results from several factors, such as:

1. Many Technical Institutes competitively build and develop complete machines in accordance with their ideas of local requirements. Although development is to some degree cooperative, factory engineers do not appear to have final authority.
2. As manufacturing technology has developed and improved materials have become available, full advantage has not been taken in the design.
3. The final decision as to what a particular factory must build is made by the Scientific Advisory Council of the Ministry of Agriculture.
4. Original designs and research can not involve prolonged work without permission of the Ministry of Agriculture.

### Denouncements Feared

Perhaps the most potent deterrent to initiative is the fear of de-



75 hp two-direction Diesel Tractor with double oneway plow.

## Russian Farm Machinery

. . . continued

nouncement by some segment of the Communist press, or by some political organization. Ubiquitous party members, without engineering training, participate actively and aggressively in directing and criticizing manufacturing and engineering activities.

In a non-competitive society (except upon the individual level, where competition is actively promoted) engineers are free to discuss future plans and trends without fear that some competitor will steal the show, or customers go on a buyers strike, awaiting new models. Advance models of tractors and machines were exhibited at Brussels, some of them far from the production stage.

# Advanced Design Features In Tomorrow's Soviet Tractors

ADVANCED design features discussed by Russian engineers in their factories, institutes and machine testing stations include the following:

### 1. Use of Air Cooled Engines:

The Kharkov Tractor Assembly plant is building a pre-production pilot run of tractors powered with a 2 cylinder air cooled engine developed at the Kharkov Tractor Works. This is a very clean cut engine, which develops 20 hp at 1750 rpm. It uses a Ricardo type combustion chamber, with an individual fan cooling each cylinder and a centrifugal type oil cleaner built into the cooling fan drive pulley. At the Moscow Exhibition, the Vladimir Tractor Works showed a similar four cylinder engine mounted in a DT28 chassis. Production is well over a year away, but a special plant to manufacture air cooled engines for all requirements is planned.

### 2. Rolled Spur Gears:

The Kharkov Tractor Works has developed a spur gear rolling process, combined with an induction heater, to produce low speed heavily loaded gears. They claim increased life up to 60% as compared with cut gears, and an increase in beam strength of 20%–30%. Now limited to pilot production.

### 3. Higher Field Speeds:

Implements built up to now have been designed for operation at horsedrawn speeds. Work is actively under way at several of the Institutes to develop plow shares and other soil working implements which will work satisfactorily at twice present speeds with even higher target speeds. These high speed implements, in turn, will require much greater power for their operation. This has already resulted in some measure of tractor redesign.

### 4. Greater Power:

The power of the 1959 wheel tractors will be from 5 to 25% greater than those built up to this time.

### 5. Tillage of Irrigated Soils:

It is planned to bring into new production 1,250,000 acres of land requiring irrigation in Usbakestan. The new DT75 crawler tractor has been experimentally developed for this purpose, but no decision has been made as to where it will be manufactured. This tractor has two opposed driver's seats, can be operated in all speeds in both directions, and is provided with two one-way plows, mounted on either end, for plowing irrigated land.

### 6. Weight Reduction:

Ready for production within the near future is the Model DT56 Crawler Tractor. It is a lighter weight version of the current DT54 model, with a 55 hp engine. Weight is reduced 2200 lb, lowering its specific weight to 193 lb. per engine hp.

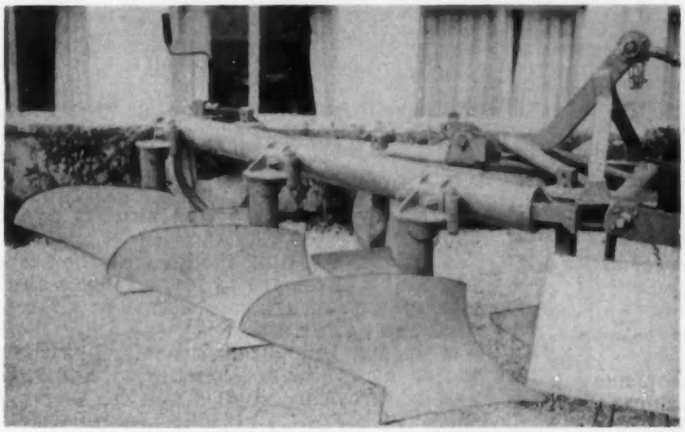
### 7. Increased Use of Wheel Tractors:

Overall plans call for raising wheat in areas unsuited for corn growing. A considerable quantity of present wheat land will then be planted to row crops increasing the need for row crop tractors and implements. It was stated that by 1965, the production of wheel tractors will increase from its present proportion of 48% to 70%.

In general, the design of Russian crawler tractors intended for strictly farm service follows original lines. These have tracks with links of cast austenitic steel with a minimum manganese content of 13%. Since it is impossible to machine this material, these one piece links with pads are assembled just as they come from the steel foundry after cleaning.

Holes for the track pins are cored large enough to permit driving carburized, hardened 20 mm (0.787) diameter link pins into place, which are held by bent pins, similar to hog nose rings. Repair

3-Row Beet Harvester on exhibition at Brussels World's Fair. At the right is the elevator with hopper.



Three Bottom Tubular Frame Integral Plow with 3-point attachment.

Technical Stations throughout the country supply both state and collective farm users with all needed service parts. One such station supplied complete new manganese steel tracks with pins, weighing 1400 lb per pair, for the DT54 Crawler for 900 rubles delivered, less scrap value, for a net cost of R's 836.00 ($83.60 at tourist exchange rates). This compares with a delivered cost of R's 1300.00 for a pair of 11-38/6 ply rubber tires and tubes for the Byelaruss row crop wheel tractor.

All Byelaruss DT20 and DT54 tractors, comprising over 73% of all Soviet Farm Tractors, employ a two stage engine oil cleaner. An edge wound wire element is used in the first stage, with an oil jet driven centrifugal rotor serving as the second element. The latter is of the British "Glacier" type.

As compared with the previous use of treated paper elements, such as those used in American built tractors, it is claimed that the engine oil change period has been increased from 100 to 250 hr throughout the Union, accompanied by a significant reduction in the rate of wear of crankshaft bearings, cylinder sleeves, pistons and rings.

The benefits accruing from this system of crankcase oil cleaning were stoutly defended wherever we inquired.

The quality of workmanship appeared excellent throughout, with the exception of shaved gears. These were generally little better in quality than hobbed gears (rough and finished cut) made in this country.

Both Minsk and Kharkov manufactured their own steel backed leaded bronze lined bearing shells, both as original equipment and for repairs for their own and other tractors. To reduce transportation costs and improve the delivery time of service parts, the major tractor factories manufacture many repair parts for other tractors within their trade areas. At Minsk, the value of repair parts was given as 10%–12% of the value of new tractors, at Kharkov 25%–30%.

At the Ministry of Agriculture, it was stated that the annual value of tractor and farm machinery repair parts equals 60% of the value of the new product produced. The same source is authority for the statement that by the end of 1958, there would be 1,000,000 farm tractors within the Soviet Union. But other information from this source indicates that there are less than 700,000.

The most used and abused technical terms in the USSR are "automation" and "100% mechanized." The former is applied to anything, from an automatic ball bearing manufacturing line or automotive engine piston line, both of which operate practically without human attention, to a manually loaded manure bucket, pushed along on a mono-rail by a badly overworked old woman.

Countless instances of "100% mechanized" farm operations were found to require more manual labor rendered by great brigades of women workers, following the tractors, combines and beet harvesters, than the entire time required to grow similar crops in this country.

### Dangers are Real

On an absolute basis, Soviet agriculture and the production of agricultural machinery production is far behind that of this country. But their present rate of progress, coupled with the likelihood that many stages of mechanization will be "leap frogged" i.e., avoided altogether by pending scientific and engineering developments, exceeds anything seen in the world to date. Driven by an inspired and ruthless leadership, which practices no limits to self denial, the goal of "equaling America" is indeed no idle dream. Then what?

"A Night to Remember" tells of the five iceberg warnings radioed to the Titanic. As the sixth message, "Look out for icebergs" was received, the Titanic's radio operator replied, "Shut up, I'm busy." Just 35 minutes later, the great ship, whose captain had said, "God himself could not sink it", was sinking.

There are those of us who feel that our country is now in greater danger than was the Titanic.

## What's Going on in

# Nuclear Energy?

**A review of articles appearing in** SAE Journal **during the past year shows that, while work on aircraft nuclear powerplants is showing encouraging results, the possibilities for nuclear-powered highway vehicles is dim, indeed. Nuclear energy is also helping in the development of better engineering materials and fuels and lubricants.**

A REVIEW of *SAE Journal* articles on nuclear developments during the past year shows that:

- Work on aircraft nuclear powerplants is proceeding apace, with interesting developments reported in regard to nuclear test facilities, and propulsion schemes for orbiting and space vehicles.
- Nuclear powerplants for highway vehicles are out for many years to come. Although nuclear power is here for submarines, it is coming but slowly for ships. Preliminary studies of nuclear power for locomotives indicates that, here too, many years of development work will be needed to produce practical designs.
- Atomic energy studies are increasing our fundamental knowledge of metals and their behavior; and are leading to improvements in various products and processes.
- Nuclear research is helping to produce better fuels and lubricants. High-level radiation tests indicate that special radiation-resistant lubricants will have to be developed for use within the biological shield of reactors.

**A report of the**

**SAE Nuclear Energy Advisory Committee**

## aircraft developments

A survey of the reported aircraft developments shows that:

- Extensive testing facilities are being built and procedures developed to test complete aircraft nuclear propulsion systems, and their materials (Fig. 1) and components.
- Nuclear propulsions schemes like the conventional nuclear rocket, ionic drive, and free radical engine are being studied for orbiting and space flight.

*Facilities* — One of the facilities being built for the evaluation of aircraft systems in a radiation environment is Lockheed Nuclear Products' new laboratory near Atlanta, Ga. This laboratory is being planned to:

1. Provide for dynamic testing of aircraft systems in realistic radiation fields; that is, in fluxes comparable to, and in some cases in excess of, those expected to fall on the particular system at its most likely location in a nuclear-powered aircraft.
2. Have the ability to handle large test articles rapidly.
3. Possess adequate handling and testing capability. It must be possible to move large test articles to and from the reactor safely, with means provided for evaluating them before, during, and after irradiation without exposing personnel to excessive radioactivity.

The isolated Idaho test site located at AEC's National Reactor Testing Station has been used by General Electric to test a complete direct-air-cycle aircraft nuclear propulsion system. The test, known as heat-transfer reactor experiment No. 1 (HTRE-1), was carried out to determine operating characteristics and to verify design of the system.

Initial tests were run from December 1955 to February 1956. The operations were:

1. Making the reactor critical.
2. Running low power tests in which air coolant was supplied by blowers.

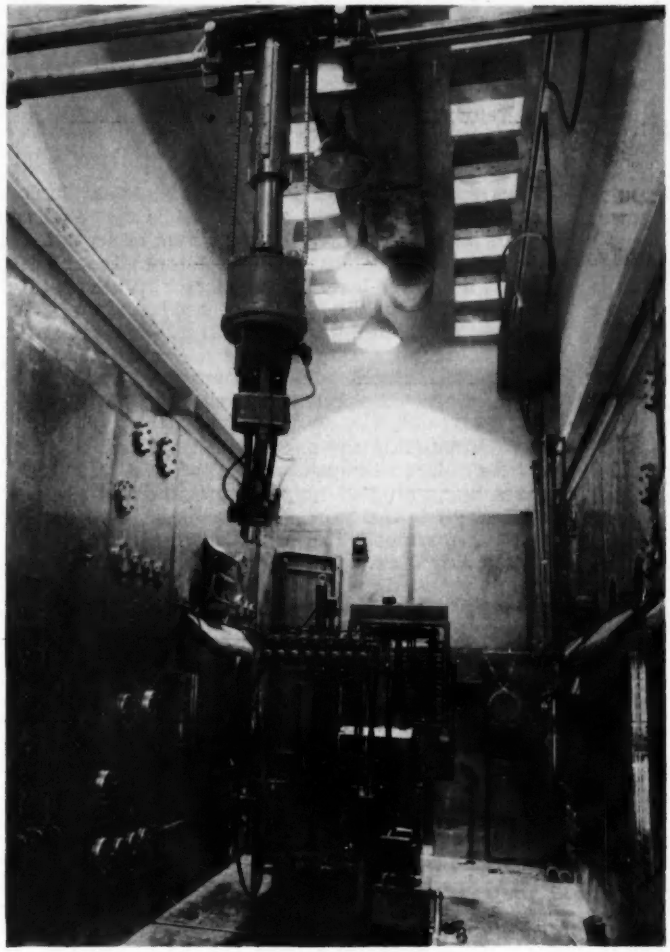


Fig. 1

**General Electric's radioactive materials laboratory**, shown here, is on one side of the "hot" shop and connected with it via a remotely operated plug door. In this so-called "hot" cell highly radioactive components can be viewed through windows and periscopes, dissected by metallurgical and machine tools, and examined in a variety of ways, all by remotely operated equipment. The huge manipulator (shown mounted on a crane bridge) will lift 40–750 lb, depending on the position of the hand. Normally, the room is a gadgeteer's paradise — filled with tables on which are placed the tools and apparatus for doing this work; a remotely operated lathe, milling machine, and grinder; also, scissors, specimen-mounted presses, a canning machine, and a balance accurate to a milligram. After completion of examination, radioactive components are literally "canned up," that is, placed in lead pigs for transportation to other locations.

3. Running tests with the engine supplying coolant air where the energy for the engine was supplied by both the reactor and the auxiliary chemical source.

4. Operating the engine exclusively on nuclear energy.

*Propulsion Schemes for Space Vehicles* — For flights in space, where air resistance is negligible and gravity greatly reduced, it appears that some form of nuclear-propelled rocket will be the most suitable means of propulsion. The main reason is that it can generate low values of thrust for the long periods of time that will be needed for any journey through space. (To get the vehicle off the ground and out of the atmosphere, chemically fueled rockets still seem best.)

One of the most promising systems for ready development, despite present shortcomings, is the nuclear rocket, in which the oxidizer is replaced by a reactor. In this scheme, a fuel — such as liquid hydrogen — is used as the reactor coolant, which becomes heated and is ultimately ejected at high velocity. The possibilities of this system for extended planetary travel seem to be limited, however, due to the difficulty of storing and transporting the hydrogen for long periods. It does appear to offer potential for short-duration flights, only, such as to the moon.

Probably the most intriguing ideas revolve around the possibility of all-electrical rocket propulsion systems. One system being considered involves the use of a rather small nuclear reactor to drive a turboelectric generator. The electrical energy would be used to accelerate ions and electrons in a thrust chamber (acceleration grids). The propellant required in this particular system must have a high atomic mass, coupled with a low ionization potential. It appears that such an ion propulsion rocket can be

## What's Going on in Nuclear Energy?

... continued

expected to extract about 50 times more impulse than a chemical rocket, and that the reactor power required is 50–100 megawatts.

The biggest deterrent to the successful application of ionic drives is not the reactor, per se, but the problems associated with electrical generating equipment. Present equipment is so heavy that it limits rocket performance severely.

A better approach to this problem of weight—and at the same time more conjectural—lies in the development of thermoelectric conversion devices; that is, methods for obtaining electrical power directly from the reactor without the intermediate thermodynamic cycle and its attendant complex of electrical generating apparatus. These schemes range from operating a pressure wave against a magnetic field in a fusion-plasma device to utilizing the solid-state properties of semiconductors.

The recently announced thermoelectron engine uses a temperature gradient between two plates, with a consequent flow of electricity. An efficiency of 12% has been obtained, which is extremely gratifying at this early stage inasmuch as normal steam-electrical power plants report efficiencies of slightly over 25%. Besides, it has been forecast that a 30% efficiency can be achieved eventually. Apparently, a powerplant using this principle could be built to yield as much as 15 kw per cu ft of volume. The best conventional plant has a capacity of 0.3 kw per cu ft. It thus appears that if a development such as the thermoelectron engine meets its promise, the use of an ionic drive with direct conversion offers a desirable direction for space travel.

Fig. 2 shows the essential features of an electrically propelled space cruiser conceived to travel from an orbit outside the earth's atmosphere to, say, an orbit near Mars. The payload includes the crew and quarters, stored atmosphere, food, water, instruments, landing vehicle, and exploration equipment.

The high energy content of free radicals makes them attractive as sources of energy for propulsion of space vehicles or aircraft. But free radicals present problems that preclude their use as propellants at this time.

With solid free-radical propellants, the problems include diluent losses, storage penalties, and dissociation losses.

With gaseous free radicals, such as the atomic oxygen found at 60-mile altitudes, the length of the catalytic bed needed to recombine the atoms would create too much drag for the powerplant to overcome. It might be possible, however, to recombine the atoms by compression, if the speed of recombination is great enough. Aerojet-General is reported to be investigating the possibility.

### ground and marine possibilities

Barring a completely unanticipated technological breakthrough, atomic energy is not going to be practical for highway vehicles. Moreover, much development work will be needed for it ever to have possibilities for locomotives. The main reasons for this state of affairs are:

- Large size (and weight), because of shielding requirements.
- High cost of fissionable material.
- Complicated controls and safety hazards.

Size and weight characteristics of nuclear fission reactors depend mostly on the shielding required. The usual biological shield comprises at least 5-ft-thick concrete (weighing about 40 tons) around the core. The power level of the reactor influences the thickness of shielding required only slightly. For this reason, shielding weight and size are relatively much more important in low power applications, such as for highway vehicles, than they would be in large powerplant applications, such as ship propulsion.

As for reducing the amount of shielding, there is nothing in sight except the "shadow shielding" techniques being studied for military aircraft. Shielding from high energy radiation is so much a matter of simple mass of material that it is hard to suggest how the shielding problem might be reduced to manageable proportions for applications involving close contact with the general public.

The high cost of fissionable material is likewise a clear deterrent to the use of atomic power on the highway. At the present AEC price of $17,000 per kg of U-235, the minimum fuel investment for a fission reactor would be $20,000–30,000.

The prospects for cheap fissionable material are, moreover, still far in the future. It appears unlikely that an equilibrium price would be lower than, say, 10% of the present level.

At present, nuclear reactor controls are complicated, and considerable simplification will be necessary to make them satisfactory for general public use. The hazards involved in accidents that might destroy the nuclear reactor and discharge large amounts of radioactive fission products in the atmosphere are apparent. While some sort of catastrophe containment could, no doubt, be built into these plants, especially for railroad and aircraft applications, the opportunities for a major disaster would always be present. As with the size and investment limitations, the hazards problems assume less significance in the application of atomic power to the propulsion of big ships, largely because of reduced traffic density and relative isolation during most of the operating period.

Ship operators are, however, reported to be showing a considerable lack of enthusiasm for nuclear-powered vessels.

At recent Congressional hearings the Navy, the Department of Commerce, and potential operators were all against a proposal to build two nuclear passenger liners. Reasons given included:

- Cost of construction and operation would be too high to be competitive.
- The vessels would probably be obsolete before they could be launched and would certainly be outmoded long before the end of their useful life.
- There is not enough experience with such ships to justify them at this time.
- There are still some uncertainties relating to insurance and possible hazards.

All this, of course, is not to say that no progress is being made. As is well known, the first nuclear-powered merchant vessel — the NS Savannah — is already being built and contracts have been awarded for the development of a converted tanker.

The Maritime Administration and the AEC have also contracted with General Dynamics Corp. to perform research and development on a gas-cooled nuclear reactor for a ship. This is to be a high-temperature reactor (1300–1600 F) with a closed-cycle gas turbine. The program is expected to lead to a prototype reactor in 5–7 years.

## better materials and processes

Rapid strides have been made in understanding the plastic behavior of metals as a result of acceptance of the concept of dislocations in crystals as one important type of imperfection. This progress has been aided by neutron bombardment of metals and alloys at low temperatures to produce imperfections in the crystal structure.

Rearrangement and interaction of these imperfections can be induced by subsequent controlled annealing and studied by measuring structure sensitive physical property variations. This will thereby provide information about metal structure changes that cannot be obtained in any other known manner. Fundamental studies of this kind can lead to the design of alloys with higher strength, better fabricability, and improved physical properties.

Fundamental knowledge of the aqueous corrosion of iron is being acquired through the use of radioactive technetium compounds.

Closer to product application and process improvements a number of developments utilizing radioactive isotopes have been reported, among them being:

- Wear of cutting tools can be followed very closely by radioactive counting of swarf produced by the tool after it has been irradiated in a reactor.
- Pinholes in tinplate are identified by flooding the plate surface with a cobalt-60 chloride solution, washing, then counting. The radioactive cobalt is deposited by exchange with the exposed iron surface in the pinhole. Plating procedures can thus be studied.
- Autoradiographic methods are being used to improve continuous casting of steel and aluminum.
- Radioactive isotopes for radiographic examination of components often have definite advantages in portability and cost over standard X-ray equipment.

Finally, a host of benefits to the automotive field is accruing from the solution of metallurgical problems in the area of reactor technology. Improved welding techniques used in fuel element and component fabrication, development of special stainless steels and zirconium alloys for reactor core applications, and better understanding of the causes of stress corrosion are examples.

## improved fuels and lubricants

*Fuels* — The effect of irradiation on fuel is being studied by the Denver Rio Grande Railroad Laboratory as a means of reducing diesel fuel particle sizes, and thereby improving fuel burning qualities. Limited tests have shown, for example, that certain fuels are definitely improved in this respect — and that these effects can be maintained for as long as 60–90 days. (Many problems will, of course, have to be solved before large volumes of fuel can be irradiated economically.)

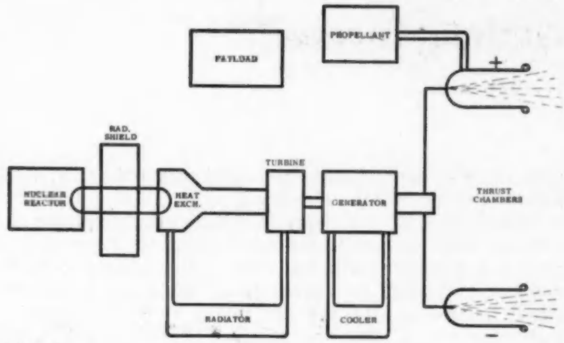



**Fig. 2**

**Essential components of an electrically propelled space cruiser** for flight from an orbiting space station 1000 miles from Earth to an orbit 600 miles from Mars (the second stage in a 3-stage flight). Payload includes crew and quarters, stored atmosphere, food, water, instruments, landing vehicle, and exploration equipment.

These irradiation studies are proceeding along two main lines:

- Irradiation of powered coal so as to produce particles small enough to be dispersed in diesel fuel.
- Irradiation of liquid fuel to reduce particle size and thereby assure better combustion.

The University of Michigan Project Phoenix was reported to have studied the effects of radiation on burning of hydrocarbon-air mixtures, finding that:

1. Intensive irradiation of a propane-air mixture prior to burning can produce a 20% increase in the air specific impulse.
2. Rate of flame propagation in a bunsen flame could be increased 50% through beta radiation of the propane-air mixture before burning.

Research is continuing on the effect of alpha radiation on ignition and combustion in a closed combustion chamber.

*Lubricants* — Continuous monitoring of lubricating oil in a car containing radioactive rings was used by Esso engineers to determine, among other things, the ability of various additives found in a compounded motor oil to reduce ring wear.

These tests showed that the detergent-inhibitor was the only additive that had any effect on startup wear at low temperature. Neither V. I. improver nor

zinc dialkyl dithiophosphate had any effect on the amount of ring wear obtained.

The failure of the zinc dialkyl dithiophosphate to reduce wear under these conditions is in contrast with some other studies on piston ring wear and with results obtained in valve lifter wear studies. In these tests the additive did prove very effective in reducing wear. It appears that the mechanism of ring wear at low temperatures is quite different from that operating at the higher temperatures studied by the others and also different from that operating between valve lifters and cam lobes.

Radioactive phosphorus is being used as a tractor in the study of the film-forming mechanism of zinc dialkyl dithiophosphate as an extreme-pressure additive. These tests have shown that:

- A chemical film is formed on the surface.
- The amount of bound phosphorus is dependent on surface treatment, and increases with time and temperature until equilibrium conditions are reached.
- Dynamic test conditions greatly increase the amount of bound phosphorus in the film, indicating that surface temperature, pressure, or wear has a marked effect on film formation.
- Quantity of bound phosphorus in dynamic tests increases with load and speed.
- Amount of bound zinc in the static tests increases as a function of temperature, but not as rapidly as bound phosphorus.

Conventional petroleum-base lubricants — both oils and greases — are expected to operate satisfactorily in most components of a nuclear power installation. With the core itself, however, hydrocarbon lubricants would be damaged beyond tolerance limits within hours or days. Graphite or molybdenum disulfide is recommended when lubricants are required under such intense radiation.

Lubrication problems of nuclear-powered seagoing vessels appear to be of the same order of magnitude as those for stationary power plants.

Problems in nuclear aircraft systems may be more serious. Limitations of space and weight necessitate compact installations and minimum shielding, exposing lubricants to more intense radiation.

One organization working on this problem, Southwest Research Institute, reported that high-level gamma radiation can produce almost instantaneous failure of modern aircraft lubricants. These failures are in the form of rapid viscosity rise and loss of heat conductivity, and the lubricant can become excessively corrosive.

Although gamma radiation (using cobalt-60) was used in these tests because it leaves the test equipment and fluids with no induced radioactivity, so that detailed inspection is easy, neutron irradiation would probably be even more damaging.

# Selecting

# For

Based on report by **David C. Killian**

United Air Lines

FLIGHT simulators are one of the key tools to be used to train pilots for jet transports. This is one indication of the intensive programs planned for training pilots specifically for the jet they are scheduled to fly.

## training with flight simulators

Captains of turbine-powered aircraft will be making daily decisions involving 5 to 10 million dollars and to insure the sound basing and effective execution of these decisions no effort is being spared to see that crews get adequate training. Flight simulators will shorten the training period and permit more intensive and broader indoctrination. Moreover, this tool is valuable in sharpening a knowledge of emergency procedures which are sometimes passed over because of the economics involved. The high cost of jet aircraft operation makes the use of simulators imperative, as well.

While no serious difficulty is anticipated in the processing of crews for transition from conventional transports to jets, there is agreement on the need for a thorough grounding on the powerplant and drive mechanism. Transition programs are to give the pilot a firm foundation of knowledge on which to build with flying experience. During this phase the pilot is learning the operation of the aircraft and becoming familiar with it. Further training is required on the airplane for the specific mission.

No added physiological problems in normal flight are to be expected, but the problem of rapid decompression to high ambient temperatures is very real and it may be assumed that acute hypoxia and gas problems will become major considerations. In cases of depressurization, the physical condition of the pilot and his knowledge of the various physio-

# and Training Pilots

# Turbine-Powered Transports

logical problems of high altitude will be important in the safe continuation of flight.

### ground school training programs

Boeing's ground school program for commercial transports covers three weeks and gives 120 hr of academic training to familiarize crews with the aircraft and its systems. Flight training for the captain assumes a prior 4–6-hr instruction in a procedures trainer but no experience with a simulator. This course takes about 10 hr of flight time coupled with approximately 2½ hr for ATR check.

Primary problems in flight transition, according to Boeing experience, are airspeed controls (apparently a product of the present airspeed indicator), control during initial climb due to requirement for close adherence to optimum speed for noise abatement, and cross-wind landing techniques which are characteristic of the swept-wing aircraft. Accordingly, the flight program puts emphasis on pre-take-off planning, take-off technique, cruise control procedures, high-speed characteristics, and approach and landing techniques.

Training of air carrier groups being carried on by Douglas will be centered around a DC-8 flight simulator. Each crew will get 15 hr of simulator training, which is expected to make possible completion of average airline pilot's flight training in 3–5 hr.

A full week of training in aerodynamics, performance and flight characteristics is planned for the Convair 880 ground school. Convair relies principally on slide transparencies as primary training aids. Static three-dimensional mockups and models are used where necessary. A cockpit procedures trainer will be used to facilitate instruction in checkout and systems operation before actual flight training.

United Air Lines has a ground school course of 112-hr duration. Extensive use of the Link-developed DC-8 flight simulator with added motion and visual landing simulation will make possible transition of the average crew in 20 hr of flight simulator training and 12 hr of aircraft flight training.

### higher standards will rule

The use of flight simulators is essential, according to TWA, because of the high cost of jet operation. Other essentials seen are: more comprehensive and thorough ground school instructor training, preliminary home work study for flight crews, use of classroom training devices, and much higher standards for flight instructor and flight crew training than hitherto thought acceptable. TWA plans to add visual landing and take-off simulation to their jet simulators in the expectation of making a substantial reduction in actual in-flight training and reduction in cost while accomplishing a better training job in low-altitude maneuvers.

Trailerized 707 flight simulators will be used by American Airlines. The training program for flight crewmen will take three weeks and, aside from the simulator, the only training aids will be Vu-Graph transparencies and 35-mm slides.

Basing on several years of experience with the C-130, Lockheed sees little difficulty in training crews to go from conventional props to turboprops. The major need is to acquire a thorough knowledge of the powerplant, which will call for more concentration on it at ground school and perhaps somewhat longer training time.

Information presented in this article was contributed by the following panel on, "Selecting and Training Pilots for Turbine-Powered Transports": C. M. Christenson, United Air Lines, chairman; David C. Killian, United Air Lines, secretary; C. R. Barron, Lockheed Aircraft Corp.; J. G. Brown, United Air Lines, Inc.; J. C. Flanagan, American Institute of Research; W. B. Harwell, Convair Division of General Dynamics Corp.; A. M. Johnston, Boeing Airplane Co.; John Martin, Douglas Aircraft Co., Inc.; R. F. Rowe, Trans World Airlines, Inc.; and R. L. Thoren, Lockheed Aircraft Corp.

# CAR Measures Customer Acceptance of Gasoline

**Customers' Antiknock Rating combines correlations of Road octane ratings and fuel properties for specific cars and speeds. It yields ratings that accurately indicate the percentage of cars a gasoline will satisfy. Such an approach is said to get us closer than ever before to measuring over-all customer acceptance of gasolines.**

Based on paper by

**Lamont Eltinge, H. R. Taliaferro, and T. O. Wagner**

Research and Development Department, Standard Oil Co. (Ind.)

THE Customers' Antiknock Rating (CAR) of a gasoline is its Research octane number corrected for the effects of other fuel properties on car satisfaction. It is related to the percentage of cars the gasoline will power without knocking. Even in simplified form, it gives more realistic results than the Research rating.

The use of CAR improves comparisons of gasolines, quality control, evaluations of processes, and projections of future antiknock quality.

### Derivation of CAR

Customers' Antiknock Rating is derived by general techniques. It can be developed for any number of fuel properties. Correlations for any number of car makes and rating speeds, and for both full and part throttle, can be used. Knock at all speeds can be considered equally important, or certain speeds can be given extra weight. All cars can be considered equally important, or satisfaction of specific makes can be emphasized. A reasonable specific derivation for current cars and fuels can be based on a few premises: Research octane number, sensitivity, and olefin content are the most important fuel properties. Ten makes represent the car population, four or five rating speeds describe performance of each make, and full throttle is the limiting condition. Knock is equally important at all speeds, and single cars of each make are given the same emphasis.

Very briefly, the derivation of such a CAR consists of four steps:

1. Express the correlation between Road ratings and fuel properties for each car make and each speed as an equation, and compute the Road ratings for one combination of fuel properties.
2. Subtract the octane requirements from the computed Road ratings and, from the differences, find the fractions satisfied.
3. Select the minimum fraction satisfied for each make, and combine these fractions to find the percentage of the total population satisfied.
4. Adjust the assumed Research octane number until the desired percentage is satisfied.

These four steps are repeated to find all practical combinations of Research octane number, sensitivity, and olefin content that satisfy the target percentage of cars. All these fuels have the same CAR.

### Applications

CAR can be applied to comparisons of gasolines, refinery control, process studies, and projection of future octane levels.

Comparisons of the antiknock quality of gasolines are more realistic on a CAR basis. Fig. 1 shows CAR and corresponding Research octane number for premium-grade gasolines surveyed recently in Detroit. The use of CAR increased the spread in antiknock quality and changed the ranking of the brands. Gasoline C ranked third in Research octane number; actually, it provided the highest level of customer satisfaction of all the brands sampled.

Use of CAR enables a refiner to make gasolines that provide more uniform car satisfaction. For example, as shown in Fig. 2, large variations occur even when gasolines are made close in Research octane number. The spread to include 95% of the samples is three times as great for CAR as for Research octane number. Blending to a CAR specification would improve uniformity in car satisfaction, but use of CAR is more complex than use of Research octane number. Refiners must consider blending procedures, sale against Research octane number specifications, uniformity of refinery operations, and

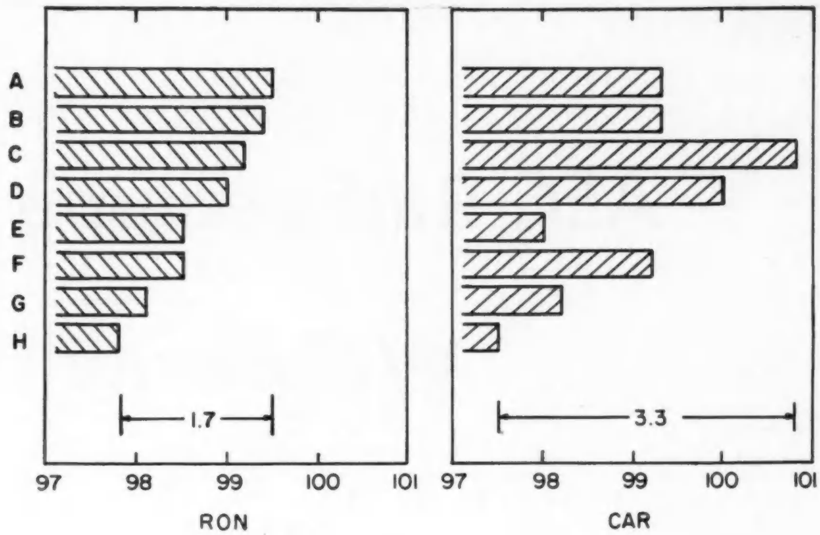



Fig. 1—CAR and corresponding Research octane number for premium-grade gasolines surveyed recently in Detroit.

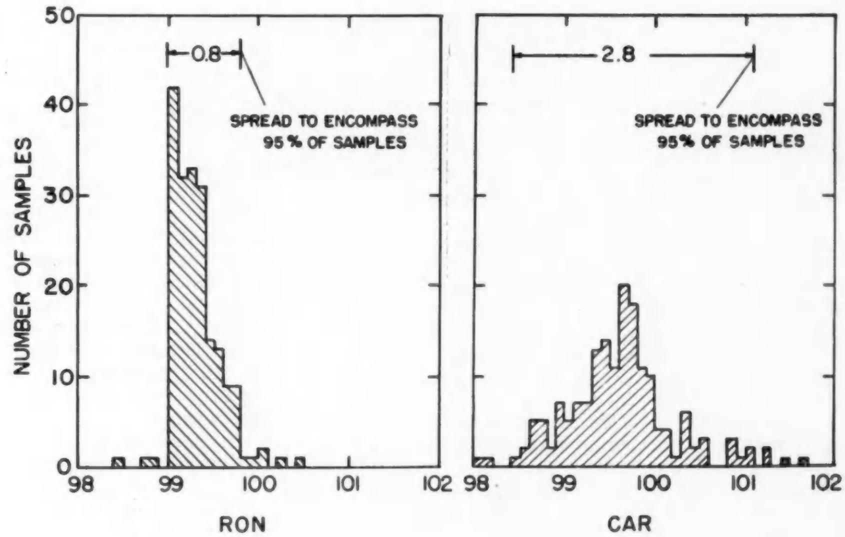



Fig. 2—Refinery quality control comparison shows how large variations occur even when gasolines are made close in Research octane number.

increased costs for quality control when selecting the best way to apply CAR.

CAR permits a more realistic appraisal of the economic attractiveness of different refinery processes. It gives a process proper credit for direct and indirect effects on the sensitivity and bromine number, as well as the Research octane number. In many cases, the use of CAR prevents selection of the wrong processing system.

Refiners make projections of future octane levels and use them as guides for decisions about new processing units that may take several years to design and build. CAR permits more realistic projections and permits trading between fuel properties in the selection of processing. Estimating future octane levels in terms of Research octane number alone is not adequate; allowances must be made for sensitivity and composition. Consequently, to ensure satisfying the target percentage of cars, projections must be expressed in terms of CAR or some similar rating.

Note: The complete paper on which this article is based gives the derivation of CAR in more detail, and includes tables of coefficients and requirements. It also suggests certain approximations that help to reduce experimental work and computations. Such approximations may be used in applications where less accurate ratings are satisfactory.

**To Order Paper No. 105B . . .**
. . . on which this article is based, turn to page 6.

A feature of the

SAE Nuclear Energy Advisory Committee

# AEC Radioisotope

# Will Benefit

Reported by

**E. D. Reeves**

Member, SAE Nuclear Energy Advisory Committee

AEC's new program for the accelerated development of radioisotopes and high-level radiation for industrial use covers three phases:

- To make radioisotopes available in greatly increased quantities and at prices that will encourage both their use and their production by private industry.

- To let out contracts for the development of new uses for isotopes and nuclear radiation in industry.

- To greatly expand the opportunities available for training in the use of radioisotopes.

The Office for Isotope Development has been established by the AEC to implement this program. Its director, Dr. Paul C. Aebersold, reports directly to the general manager's office.

Expenditures of $4,000,000 are planned for 1959. Subject to Congressional approval, annual expenditures will probably be expanded to about $15,000,000 per year by 1961. The program will then be maintained at that level for the next few years. Thereafter its magnitude will gradually decrease as its objectives are accomplished.

### Increased Production

AEC's isotope production activities are to be appreciably expanded. Production per year of both cobalt-60 and hydrogen-3 is expected to reach the multimegacurie level in the near future.

The cobalt-60 production will be needed to supply the radiation sources for the high-level irradiation facilities AEC is planning. Hydrogen-3 demand is expected to arise from a number of industrial applications, such as the manufacture of self-luminous light sources.

AEC is also changing its licensing policies to encourage large-scale applications for isotopes. For example, it recently published new regulations that list the conditions under which certain radioisotopes can be incorporated at very low and safe levels in products sold to the public without requiring that such products be labeled as radioactive. This regulation should be particularly effective in opening up new uses for isotopes in the petroleum industry for the identification of products and for the investigation of refining and blending operations.

With this increased production and these liberalized licensing policies, radioisotopes should find greatly expanded uses in industrial plants and also as sources of radiation for the initiation of chemical processes.

It is estimated that less than 1% of the industrial concerns in the United States now use radioisotopes. In applications in which radioisotopes have proved of commercial value, such as thickness gaging, the market for such instruments is less than 10% saturated. Even at this low level of use, however, industry is already realizing significant profit from the use of radioisotopes.

### Joint Research on Industrial Uses

AEC is inviting industry to participate in a joint effort to develop additional, everyday uses for radioisotopes important to the national economy. This will be accomplished through AEC-financed contracts for the development of new and extended applications of radioisotopes that are proposed by private industry. In reply to its request for contract proposals in this area, AEC has received a response that is more than twice what its current funds can support.

This program should encourage private organizations to find new industrial uses for radioisotopes

# Program

# Industry

and radiation, and to extend already known uses. Interest in such uses will certainly be encouraged in the companies that participate in contracts under the program. It will also be encouraged in the far larger number of companies that can take advantage of the applications that are developed.

Although the entire schedule of contracts for 1959 had not been announced when this article was written, those already released included many of direct interest to the automotive and petroleum industries.

AEC is also planning to construct at least two high-level irradiation facilities during the next two or three years. These will each contain one or more megacuries of cobalt-60. They will be made available to both private industry and contractors associated with the isotope development program. These facilities should be useful for studying the engineering design aspects of large commercial irradiation facilities and for conducting pilot plant studies on food sterilization and chemical processing.

### Expanded Training Facilities

An important cornerstone of the AEC program will be the expansion of facilities for training both industrial personnel and university students in radioisotope techniques. For this purpose AEC plans to expand its own training facilities at Oak Ridge National Laboratories by offering a 6-week course on "Industrial Uses of Radioisotopes" several times a year.

It will provide funds to assist in the establishment of courses on industrial uses of radioisotopes at colleges and universities throughout the country. Funds will also be provided to cover the purchase of equipment that will permit instruction on radioisotope utilization to be included in established collegiate courses in nuclear engineering and physics throughout the country.

In addition, symposiums on the use of radioisotopes and nuclear radiation are being planned in cooperation with various technical societies.

# Millions of Dollars

## . . . are saved annually by Pontiac's material utilization program. Every department contributes; award is recognition, not cash.

Based on paper by **C. O. Johnson**
Pontiac Motor Division, General Motors Corp.

REALIZING that material cost consumed 51% of its sales dollar, Pontiac launched a program to reduce, substitute, eliminate, or conserve both tools and materials. In 1956, the first year of operation, savings totalled $8,524,000. In 1957 they rose to $9,236,000. Last year they fell to $4,807,000, presumably because of smaller volume and the natural loss of potential as the program progresses.

The material utilization program is run by a committee having department heads or assistants for members. And with its subcommittees it permeates the entire organization. Saving is everyone's business and money-saving ideas come from every source, as the following examples will show.

Alerting the supervisory staff of the car assembly plant to watch for possible economies in the buildup of 1959 pilot run cars brought about a saving of $97,000 through deletion of parts from inner hood panel to outer panel, while analysis of the chassis wiring harness resulted in a saving of $47,000.

Oil usage in the engine plant, which has been running 2500 gal per week, will be cut to a normal consumption of 1750 gal per week.

During two production down-days in this same plant, a drive for savings proposals brought ideas resulting in $100,000 for each day.

Provision for the return of gloves, aprons, boots, sleeves, and the like, to the cribs before new or renovated apparel would be issued, then having the returned apparel cleaned and repaired by a laundry, resulted in a $35,000 a year saving.

After water requirements for the plating plant were studied, an orifice plate was installed at each point of water usage to control the amount of flow. This saved 73,448,000 gal of water in 1958.

When engines in the assembly department were torn down, removal of the sparkplug wires from the distributor cap resulted in end clips being pulled off the wires and breakage of wire inside the insulation. A suggestion to leave the wires in the distributor cap and assemble on engines in that way proved feasible and brought annual savings of $242.24.

Substituting fire clay for Bentenite in sand for cupola bottoms saves $720 annually in the foundry.

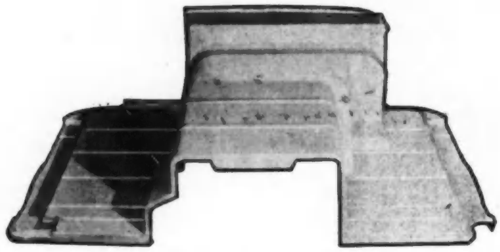
Redesigning a radio control knob spring in accordance with the vendor's suggestion saves the purchasing department 1.2¢ per spring — a small saving, but totaling $5940 annually.

Elimination of special annealing or normalizing of steel used for fabrication of front suspension control arms has saved $114,900 annually.

**To Order Paper No. 27R . . .**
. . . on which this article is based, turn to page 6.

Hard-to-make one-piece parts are chief design features in . . .

# NEW FIBERGLASS Truck-Cab



Underbody is molded in one piece.
Width, 96 in.; length, 50 in.; depth, 30 in.
(Fig. 2)

Based on paper by

**J. R. Hammond**

Molded Fiber Glass Body Co.

THE first fiberglass reinforced plastic truck-cab to reach production (Fig. 1) consists of 36 molded parts made in matched metal dies. It is 90 in. wide, 50 in. from front to back, and 70 in. high. Use of fiberglass reinforced plastic is permitting several one-piece parts that would have been impossible in sheet metal without exorbitant tooling cost.

Each of the 36 parts is molded in a set of matched metal dies in a hydraulic press. Steel plate dies are used for shallow parts; alloy iron castings for deep parts. (Both have flame-hardened telescoping pinchoffs.) Steam heats the dies to a temperature of 225–275 F, and hydraulic presses provide pressures of 100–150 psi on the molded surface.

The underbody of the cab (Fig. 2), including the entire engine compartment, is molded in one piece, which measures 96 in. wide, 50 in. long, and 30 in. deep. Ribs to increase the rigidity and to keep mounting bolts below floor level are molded into the part. Generous flanges for bonding are around the perimeter. So, when removed from the press, the part is made ready for assembly by merely drilling or punching holes and cutoffs and by scuffing the bonding areas.

Other parts that would be difficult to duplicate in sheet metal are shown in Figs. 3–9. These illustrations show the qualities which provide the wide design possibilities inherent in use of fiberglass reinforced plastic. Among the more important of these are:

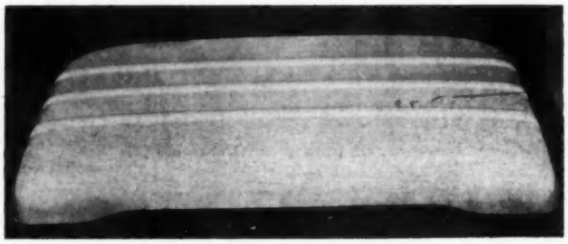
- Reduction in weight.
- Impervious to rust.
- Cooler in summer; warmer in winter.
- Reduced noise in completely bonded assemblies.
- Absence of fatigue in assembled structures.
- Lower tooling costs.
- High impact strength.
- Ease of repair.

Color is not impregnated into any of these truck-cab parts — nor into other automotive parts — for three reasons:

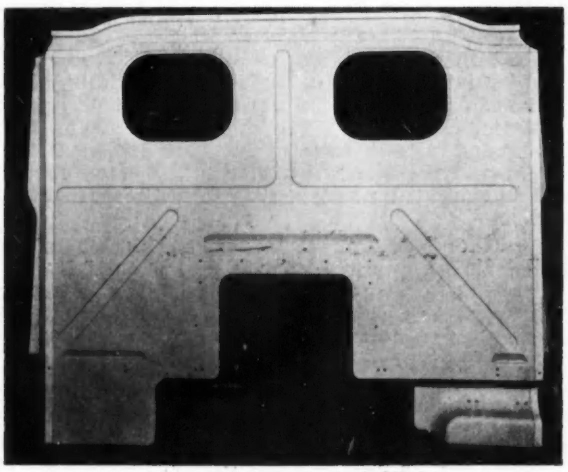
(1) It is difficult to match colors from different runs.
(2) When making assemblies where parts are scuffed and bonded, the bond must be sanded smooth, which would destroy the finish and leave a poor appearance.
(3) Repair is difficult. It is nearly impossible to match the color of a part with patching material.

**To Order Paper No. 100C . . .**
. . . on which this article is based, please turn to page 6.

## Fiberglass reinforced plastic parts



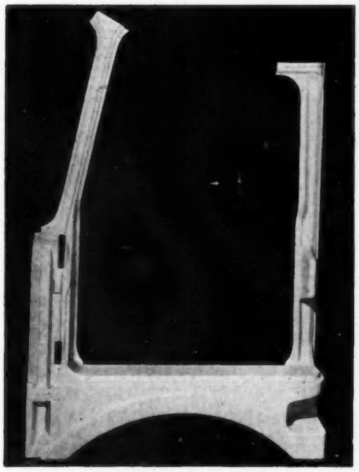
Roof panel. (Fig. 3)



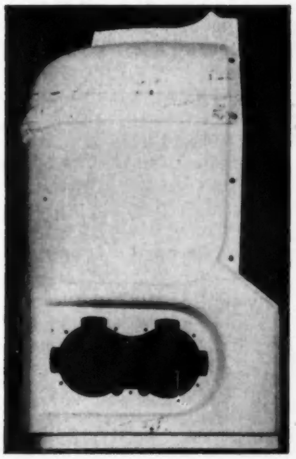
Entire rear panel. (Fig. 4)

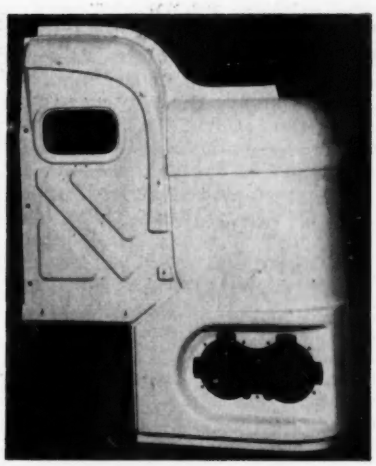
Fiberglass reinforced plastic truck cab, the first brought to the production stage by the Molded Fiber Glass Body Co. . . . which has been producing Chevrolet Corvette bodies since 1953. (Fig. 1)

## of truck-cab, which would be difficult to duplicate in sheet metal . . .

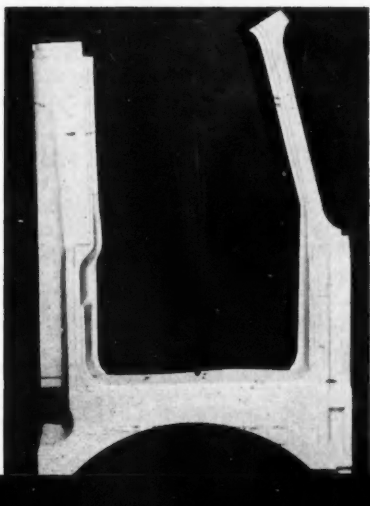


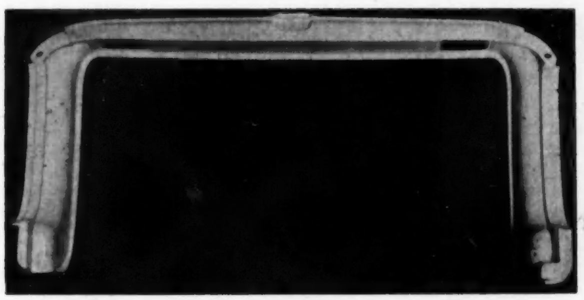
Hinge and lock pillars made in one piece. (Figs. 5 & 6)





Front quarter panels. (Figs. 7 & 8)





Roof panel reinforcement. (Fig. 9)

# Numerically Controlled Milling Machine Uses Analog and Digital Techniques

Based on paper by

**Paul H. McGarrell**

Thompson Ramo Wooldridge, Inc.

THOMPSON PRODUCTS' numerically controlled milling machine represents a marriage of the analog techniques of tracer servo control and the digital techniques of the modern computer.

Fig. 1 shows the control system as applied to a Cincinnati 16 × 30 Hydrotel. The servo electronics, which is the analog part of the control, is housed in the first two cabinets starting from the left. The next cabinet is the director, followed by the photoelectric tape reader — these two units comprising the digital portion of the control. Associated with all of these subassemblies is a central console used for general monitoring and setup.

The equipment shown in Fig. 1 is presently configured for the guidance of four machine axes — table, cross-slide, and spindle, as well as a rotary axis which is to be added to the Hydrotel. This addition will be mounted on the milling machine table and will rotate about an axis parallel to the table, the workpiece being held in the rotary fixture.

## information flow

The steps preliminary to final fabrication of a part start by feeding into an IBM 650 computer a basic numerical description of the part to be machined (Fig. 2). Along with this description the computer receives a set of detailed instructions which allow it to generate a detailed mathematical description of the part to be machined. The computer output, in the form of punched cards, provides this description. Information from the punched cards is then automatically transcribed onto punched paper tape by means of a card-to-tape converter. The punched tape is the final input to the system and is a complete mathematical description of the part to be fabricated.

Fig. 2 also shows the major subassemblies of the control as they are interrelated with respect to data flow. The basic functions of these subassemblies as data progresses through the system are as follows.

The photoelectric tape reader reads information from the punched paper tape and presents it in a form suitable for assimilation by the director.

The director accepts the discrete, digitally encoded information of the tape reader and digests this information, providing as an output a continuous, precise analog signal. One analog signal is supplied for each of the axes to be controlled. These signals, which are analogs of the motion to be executed by respective machine tool axes, are all coordinated by the director to insure proper generation of complex cuts. The analog signals are then accepted by the next major subassembly of the control — the servo system.

The job of the servo system is to compare the input command signals to feedback commands derived from the machine tool, these latter signals providing continuous positional information for each of the axes under control. The servo, then, compares commands telling where each of these axes should be to the feedback information telling where they are. The resultant error signal is used through an electrohydraulic link to guide each of the machine axes through the specific paths dictated by the punched paper tape input.

The control console is used for general monitoring and setup procedures with such items as the photoelectric tape reader and the director. The console also permits manual insertion of digital commands other than those from punched paper tape.

## operational detail of the control system

At this point we are in a position to go into more operational detail of the major elements of the control system. This detail, however, must be preceded by some statements regarding the basic philosophy of the control. First of all, referring to Fig. 3, a means of contour representation is shown. Here, a

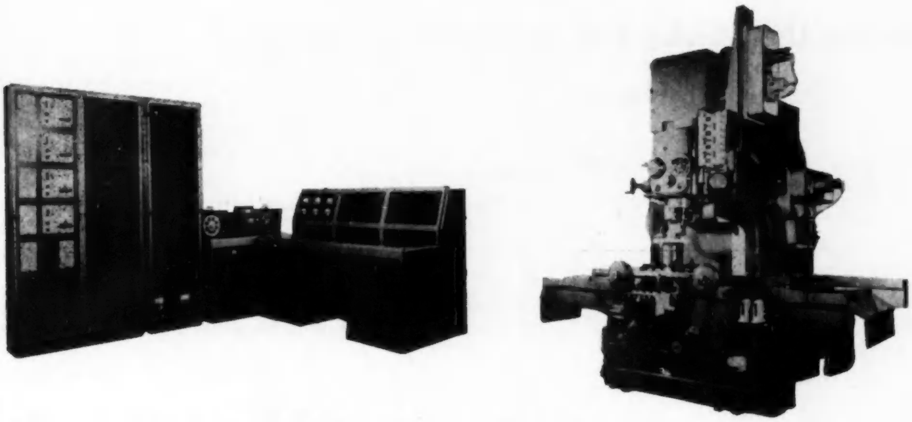


Fig. 1 — Control system for Cincinnati 16 × 30 Hydrotel. From the left, the first two cabinets contain the servo electronics. The next cabinet is the director, followed by the photoelectric tape reader. A central console is used for general monitoring and setup.

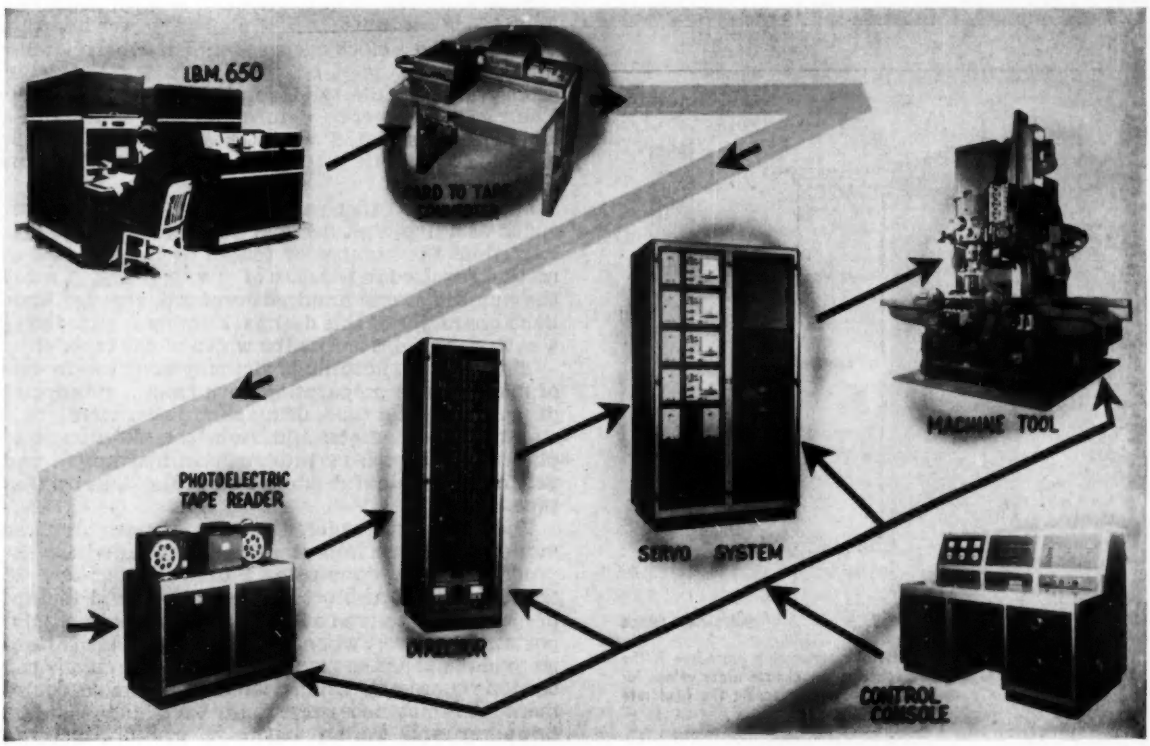



Fig. 2 — Information flow chart for a numerical control system.

# Numerically Controlled Milling Machine Uses Analog and Digital Techniques

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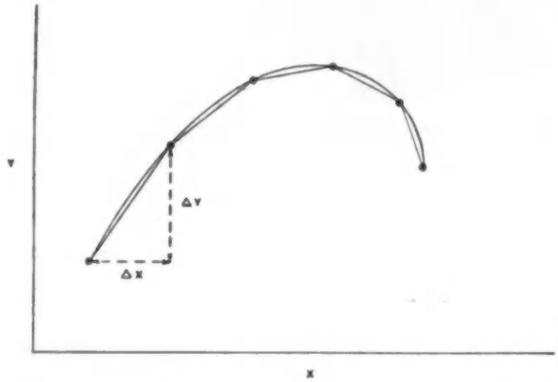



Fig. 3 — Two-dimensional representation of a desired contour is simulated by a series of straight-line segments.

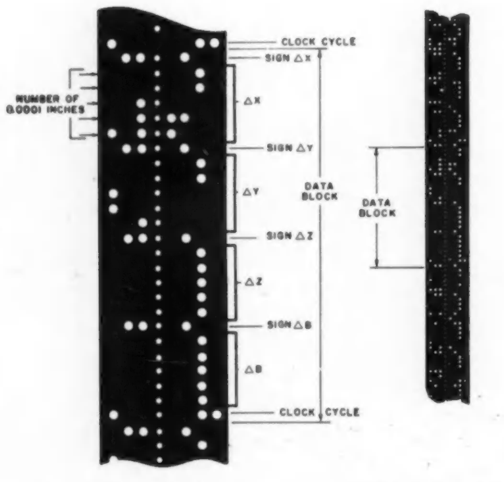



Fig. 4 — The final output of the programming procedure is the punched paper tape which contains the change order values for a given contour as well as information regarding the feed rate control.

two-dimensional case has been considered and as is shown the desired contour is simulated by a number of straight-line segments. The length and number of these segments are determined by tolerance and surface finish requirements. Note further that each of these straight-line segments is designated by a delta value, $\triangle x$ and $\triangle y$. These so-called change orders are the change in $x$ and $y$ required to proceed from point to point along the specified curve. To insure a straight-line path between points, the following must hold:

1. The velocities of $x$ and $y$ motions must be constant between points.
2. These velocities must be such that $\triangle x$ and $\triangle y$ are traversed in the same time.

Variation of this time as the machine progresses from point to point will be a means of controlling feed rate.

Programming is the determination, for a given part, of the required change order values determined from a basic computational procedure. Of course, this computation must also include consideration of feed rates, spindle speeds, cutter size, and similar items. The computation can be carried out by use of desk calculators for the more simple two-axes contours or by use of standard digital computers as the complexity of these contours increases. The final output of the programming procedure is the punched paper tape — the tape which holds the change order values as well as information regarding the feed rate control. The format of this tape, whether desk calculators or digital computers are used as an aid in programming, is the same and is as shown in Fig. 4.

Note that the data is grouped into data blocks. Each block contains a set of change orders and also what is called a clock cycle code. The change orders include $\triangle x$, $\triangle y$, $\triangle z$, and $\triangle$ *Beta* for the table, cross-slide, spindle, and rotary axes, respectively. The clock cycle code determines the time during which the associated set of change orders is to be executed. This time is a means of controlling the feed rate.

Each change order value, for instance, $\triangle x$, is encoded as a five-digit decimal number. The five digits denote the number of tenths of thousandths of motion required in the case of $\triangle x$, $\triangle y$, and $\triangle z$ and the number of one hundredths of a degree for ***Beta***. Each character of this decimal number is encoded as a pattern of holes across the width of the tape.

This type of encoding is virtually essential in case of manual tape preparation both from a standpoint of preparing the tape, using such instruments as a standard Flexowriter, and from the standpoint of playing the tape back into such an instrument and getting a meaningful tabulation of the data on that tape.

The ease with which the tape can be prepared manually is even important in a system where the programming is done using a digital computer. In this case, while using the computer to aid in tape preparation, the type of code is not particularly important; however, when additions or revisions must be made in tapes so prepared, if these revisions can be done manually using standard available equipment, it is not necessary to go back to the digital computer and tie up expensive equipment for a minor revision.

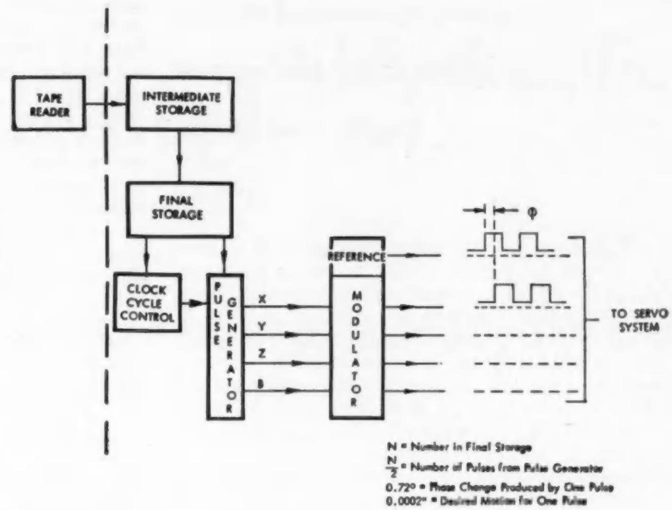



**Fig. 5 — Block diagram of the tape reader and director system.**

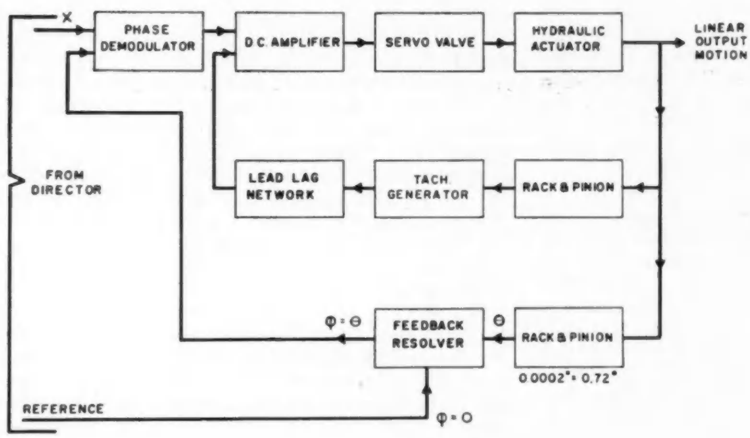



**Fig. 6 — Block diagram of a servo system for a single axis.**

Remembering the general content of the punched paper tape input to the control system, let us discuss in more detail the operation of the major subassemblies of that system. Beginning with the tape reader and director, recall that the combined function of these units is the reading and subsequent digestion of information derived from punched paper tape and final presentation, as a director output, of signals which are analogs of the motions required of the various axes under control.

Fig. 5 shows a block diagram of the tape reader and director system. This diagram is probably best explained in two parts. First, the read-in function and second, the pulse generation and modulation portion of the director. With respect to the read-in, this operation includes the tape reader, as well as the intermediate and final storages of the director. Two storages are used here to maintain an even flow of data within the director. This is accomplished as follows.

The final storage unit is used to control the digestion process within the director. As the initiation of digestion of the information in final storage starts, so also, reading from the tape reader into the intermediate storage unit is started. Timing is so arranged that a complete block from tape is read into intermediate storage prior to the completion of the digestion of information in final storage.

At the completion of digestion, information now ready in intermediate storage is transferred, in a

few microseconds, to the final storage, and a new digestion process is started. Thus, as far as practical time constants of the system are concerned, final storage has a continuous flow of information.

Pulse generation proceeds along the following lines. By means of the pulse generator, four trains of pulses are emitted — one for $x$, $y$, $z$, and the rotary axis, *Beta*. The number of pulses in each of these trains is controlled by the delta or change order information for these axes in final storage. As noted in Fig. 5, if the number for a given change order in final storage is $N$, the number of pulses in its associated pulse train is $N/2$. The number of pulses in the Beta train is $N$.

For a given block of information in final storage, the time during which the set of four pulse trains is generated is the same and is controlled by the clock cycle control which derives its initial information again from final storage in the form of the clock cycle code. Because for the linear axes the number in final storage for a given change order is the number of required 0.0001 in. of motion; each pulse in a given train indicates the number of 0.0002 in. required motion. This relation is determined from the fact that the total number of pulses in a given train is $N/2$, $N$ being the number initially derived from final storage.

Further, with this weighting on each pulse for the linear axes and a similarly derived weighting for *Beta*, each train is now an analog of the required motion. The coordination problem associated with the straight line synthesis previously explained is taken care of because each of these pulse trains is generated over the same amount of time and the pulse spacing in a given train is very nearly uniform.

As shown in Fig. 5, the set of four pulse trains now provides the input to the modulator. This unit performs the following functions. It provides as an output five separate 200-cps square wave signals. One command square wave is provided for each of the four axes under control plus a single reference signal. One input pulse train is associated with each of the command 200-cps outputs. A given 200-cps command output is phase-shifted exactly 0.72 deg with respect to the reference for each input pulse. Effectively, what is done here is to provide the same analog type signal with respect to motion at the modulator output as was had at its input, except now we have exchanged a phase difference for a pulse. Further, since for the linear axes each pulse represented 0.0002 in. and this pulse now produces 0.72 deg phase shift, this amount of phase shift is now the analog of 0.0002 in. motion. Similarly, this same amount of phase shift represents 0.01 deg for *Beta*. A set of four such analog signals, along with the reference signal, is now the required input to the servo system.

The electronics of the servo system for a single axis is shown in the block diagram of Fig. 6. The servo systems for the remaining axes are similar, with the exception of the rotary axis which differs only in the final hydraulic actuator and in the feedback gearing.

The input to the servo electronics on a per-axis basis is a command analog signal, $x$, from the director, as well as the common reference signal. The reference signal, as shown, provides electrical excitation to a feedback resolver. The resolver, driven by a rack and pinion, is a means of deriving positional information for the servo system. The rack and pinion, driven by the controlled motion, provides a certain mechanical rotational input to the feedback resolver for a given output motion.

The feedback resolver output is an electrical signal which is phase-shifted a number of electrical degrees, $\phi$, which is equal to the mechanical rotational input, $\theta$. This phase-shifted output, as well as the analog command signal from the director, are the inputs to the phase demodulator. The demodulator compares the phase of its two inputs and provides a voltage output whose sign is dependent on the direction of phase difference of the two inputs and whose amplitude is proportional to the amount of that difference.

This voltage output is the error signal of the servo system and, properly amplified, controls an electro-hydraulic servo valve which in turn controls the flow of oil to a hydraulic cylinder, the final muscle of the servo system. Resulting output motion is measured by the feedback unit, whose main components are the feedback resolver and the rack and pinion.

Another rack and pinion system drives a tachometer generator to inject a rate signal into the servo system for stabilization purposes. Motion in this system will continue until the error signal at the output of the phase demodulator has decreased to zero. A zero voltage indicates a zero phase difference of the two inputs to the phase demodulator.

Starting from such zero phase condition, the detailed system operation is as follows. Assume a given shift in phase in the analog command signal derived from the director. The feedback signal of the phase demodulator for the moment remains constant and the output of the phase demodulator will indicate an error signal, which will cause output motion. Motion will continue until the feedback resolver has shifted the phase of the feedback signal — an amount equal to the shift in the initial analog command signal.

The amount of output motion required to produce this phase shift is determined by the rack and pinion gear ratios; the over-all ratio here being such as to permit 0.0002 in. linear motion to produce an output rotation of 0.72 deg.

In the previous example, a sudden or step change of phase in the analog command signal was assumed. Actually however, this signal is a continuous analog of the required motion whose phase, therefore, is continually shifting whenever the controlled axis is to move. In actual operation, the servo system provides continuous tracking of the command signal to insure faithful following of the controlled output motion.

**To Order Paper No. S126 . . .**
. . . on which this article is based, turn to page 6.

# Future CSD's { Hydraulic Pneumatic Mechanical

***Constant-Speed Drives for aircraft a-c generators are almost ready for Mach 3 applications.***

THE constant-speed drives of tomorrow's supersonic aircraft will be improved versions of today's hydraulic or mechanical units. Pneumatic drives will be chosen for the rockets and ramjets, and will provide competition for jet engine aircraft applications. In both cases the problem is a wide operating temperature range.

Not only is it important to step up the operating temperature of constant-speed drives, but the method by which heat is rejected from them must fit in with the overall performance of the aircraft. For example, an airplane flying between Mach 2.5 to 4.0 for longer than an hour would have the following heat sinks:

- Compartment ambient.
- External ambient.
- Fuel.
- Water.
- Ram air.

The compartment ambient is the most desirable heat sink, and one of the least practical for constant-speed drives. First, the drive rejects too much heat — 300 Btu per min for a 40 kva unit — for sim-

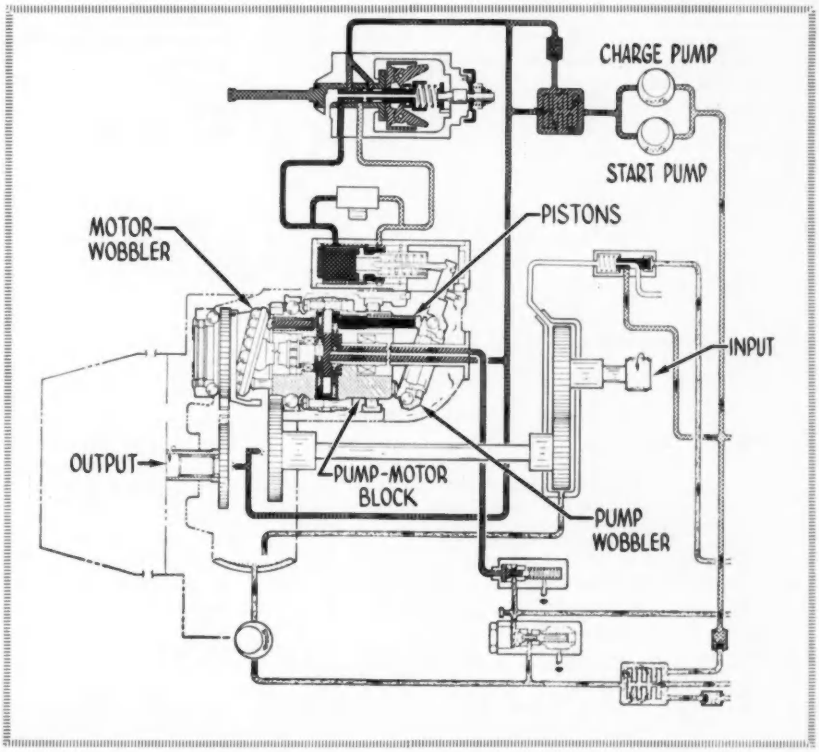



Fig. 1 — Hydraulic constant-speed drives will continue to be developed and used for powering aircraft a-c generators. Peak military usage is expected around 1961 and peak commercial usage near 1980. Only improvements in high-temperature fluids are needed for speeds up to Mach 3. A typical system is shown.

**Table 1 — Hydraulic Fluid Capabilities**

| Fluid Type | Diester | Silicone | Chlorinated Silicone | Silane | Super Refined Mineral Oil |
|---|---|---|---|---|---|
| **Lubricity** | | | | | |
| Sliding Contact | Good | Poor | Fair | Fair | Good |
| Rolling contact | Good | Fair | Good | Good | Good |
| **Low Temperature** Limit[a], F | −30 | −80 | −70 | −20 | 0 |
| **High Temperature** Limit[b], F | 500 | 650 | 625 | 750 | 700 |

[a] Minimum temperature at which constant-speed starting characteristics could be expected.

[b] Maximum "oil in" temperature to constant-speed drive for at least 50 hr of 250-hr fluid life. Balance of time (200 hr) at 70% maximum temperature. Assumes nitrogen blanketed system.

ple convection or conduction cooling. Second, the drive unit would have to operate at very high temperatures, possibly 1600 F, in order to reject heat to some of the high-temperature compartments.

External ambient cooling shows more promise when a skin heat exchanger is used. Heat would be carried from the drive unit by a fluid to outer skin panels on the side of the fuselage. For this type of cooling, constant-speed drive (CSD) stabilized temperatures would be 500 F at Mach 2.5, 670 F at Mach 3.0, and 1100 F at Mach 4.0.

Free cooling is available when the fuel is used as a heat sink. Heat from the CSD or other sources can be rejected to the fuel up to the point that is critical to the engine (which is about 230 F). This means the CSD would be operating in the already-designed-and-working range. The only drawback to this system is the plumbing necessary to transport heat to the fuel and the need for another heat sink when aircraft speeds are over Mach 2.5.

There is nothing free about water as a heat sink. However, it absorbs more heat than almost any other fluid in going from a liquid to a gas state — and is easy to supply and store. By pressurizing the water to 20 psi, water can be used to hold the fuel at its critical temperature. The resulting steam is expanded through a steam-oil heat exchanger and then discharged to the atmosphere (about 1 psi). The steam could exit at 550 F with CSD temperatures of 600 F for limited high-temperature CSD operation. Water should always be considered as a supplemental system for accessory cooling. Care must be taken to avoid freezing during arctic operations.

Ram air becomes less attractive as a heat sink as the Mach number goes up. At Mach 4.0, its temperature is 1150 F. Also, the air should be taken from the inlet diffuser to lessen the profile drag. This means that heat loads generated in flight could not be readily dissipated when the plane lands and is taxiing. Under these conditions, there may be no ram air flow.

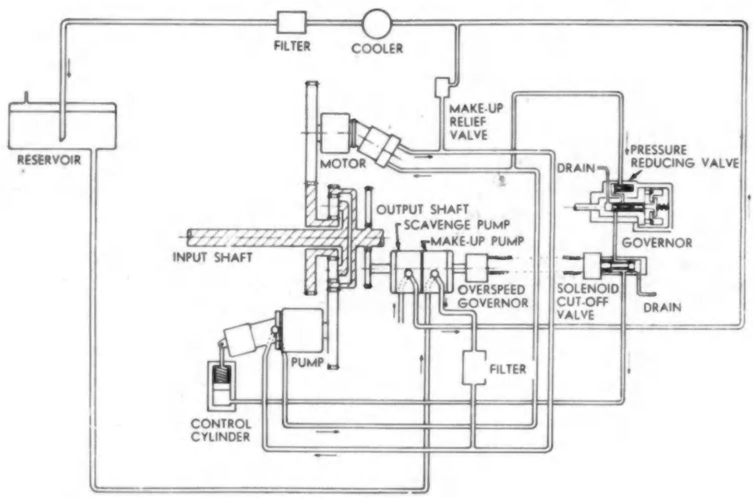



Fig. 2 — Adding a planetary gear system to the constant-speed drive improves its power handling capacity. The gear system has two inputs (one of which is controlled) and one output.

Fluids are the main limitation on high-temperature hydraulic CSD's. Other components will undergo changes, but high-temperature materials are already available for such parts as gears, bearings, seals, and housings.

Thus tool steels and high alloys will replace aluminum, magnesium, cast iron, 52100 steel, and organic elastomers.

Some of the new applications being investigated are:

**Gearing** — Halmo, Vasco Jet, Thermold J., SAE 9310, 9315, Peerless 56, Rex Supercut, Rex VM, Unimach I & II, and AISI 4000 series, using in some cases varied heat-treatment and case conditions.

**Housings** — Fabrication of stainless steel or high alloys can be brazed together to form sections of widely varying thickness from preformed components. By using steel, the differential expansion between housing and adjacent steel members is cut down. Also, dissimilar materials can be used for specific design conditions. Holding good tolerances, however, requires special fabricating procedures.

To stretch the use of magnesium for housings, a central support structure can be used to minimize expansion problems. The surface of the magnesium can also be treated with alloys such as HM21XA or HK31 to extend its use into the 500–600 F range.

**Spool Valves, Control Piston, and Governor** — M-50 or Halmo are materials that will withstand 600–700 F and the light loads experienced in these applications. The stem valve of the governor can be run in a cast grey iron sleeve.

**Circulating Pumps** — A class 40 grey cast iron looks good for internal and external gear pumps operating at 500 psi. The iron should be hardened and tempered at 800 F.

**Cylinder Blocks and Pistons** — Intermediate tool steels will suffice for the pistons and body of the cylinders. Cylinder inserts are used to give better imbeddability and dry compatibility. These inserts can be coated or bonded with: Clevite 8 bronze, M-84 iron base material, carbon graphite, silver plate, and F-105 high-temperature aluminum alloy. This arrangement replaces the present bronzes because of their corrosion, lead sweating, chemical interaction with fluids, and loss of physical strength.

**Bearings** — Halmo and M-50 steels (produced by the consumable-electrode vacuum-melted method) have been successful to date as bearing materials. However, the particular application can influence the choice of materials. Retainers for the balls, depending on the fluid used and application conditions, may be made from: S monel, aluminum bronze, iron-silicon bronze, nitralloy, or high-nickel cast irons.

Finding a fluid that is good from – 65 to 700 F with oxidation and corrosion resistance and lubricity is still the biggest problem. The present fluid line-up is shown in Table 1, along with their properties.

### Two Hydraulic CSD Designs

A typical CSD design is shown in Fig. 1. The heart of the drive is a variable hydraulic wobble pump

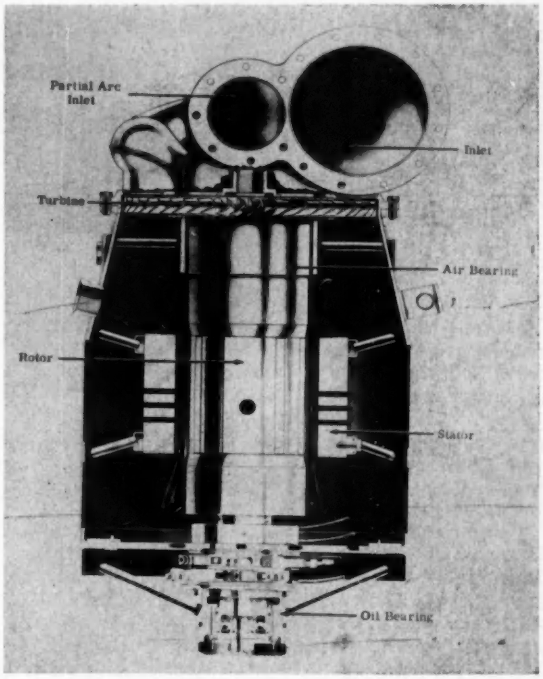



**Fig. 3 — A single shaft and set of bearings simplify a turbine-driven constant-speed drive. This unit supplies its own cooling. Improved insulation on the generator windings may move the generator temperature limit up to 800 F.**

THIS ARTICLE is based on the following papers and the discussion which occurred after their presentation:

"Adaptation of Constant-Speed Drives to Long-Range Manned Aircraft of the Immediate Future" (Paper No. 94A) by **C. W. Helsley,** North American Aviation, Inc.

"The Turbonator — An Integrated Air Turbine Generator for High Mach Aircraft" (Paper No. 94B) by **S. F. Richardson** and **J. W. Haynes,** General Electric Co.

"Constant-Speed Drives for High Mach Aircraft" (Paper No. 94C) by **F. L. Moncher** and **J. S. Cardillo,** Vickers, Inc.

"Mechanical Considerations in the Design of a Constant-Speed Transmission for Mach 3 Applications" (Paper No. 94D) by **D. L. Cauble, K. A. Teumer,** and **J. G. Castor,** Sundstrand Machine Tool Co.

**To Order Papers Nos. 94A, B, C, and D . . .**
. . . on which this article is based, turn to page 6.

Future CSD's Hydraulic / Pneumatic / Mechanical

. . . continued

backed up to a fixed wobble motor. When the motor pistons are fixed in their cylinders, the CSD output speed is equal to the input speed. By varying the angle of one wobble plate from the "straight through" position, the output speed can be increased or decreased. Control is by a flyball governor, although in future drives an electronic fine adjustment will probably be necessary on all high-performance vehicles.

The differential drive is a second CSD system that patterns itself after the cabin supercharger drives used for many years in commercial systems. A schematic is shown in Fig. 2. This is basically a planetary gear train with two inputs and one output. The ring gear is the output and the planet gears are the input. When the speed ratio needs no correction, the sun gear is stationary. If the speed ratio is not "straight through," the sun gear is rotated by a hydraulic motor in order to crank speed into or out of the ring gear. Since this system uses

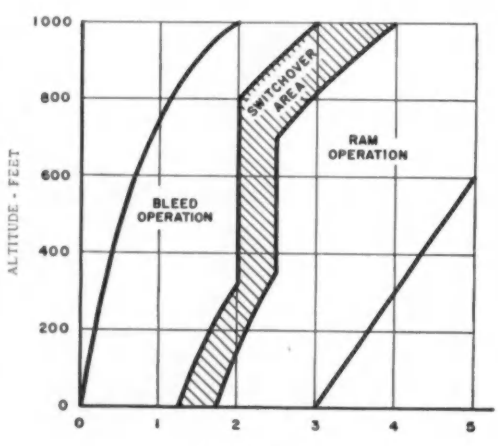



Fig. 4 — Air turbine drive switches to ram air when bleed air becomes too hot. Air may be drawn from one or more engines. A recommended location is in the bypass air duct of supersonic jet engines.

the CSD unit as supplemental drive, the size and weight of the hydraulic unit are less that for a pure hydraulic transmission of equal capacity. Care must be taken in this design when speed is subtracted by the CSD unit, for there is an internal power recirculation which can cut efficiency and durability. Also, the input speed range of the variable section increases directly with the per cent of power carried by this device.

### Pneumatic CSD

Using an air turbine to drive a 400-cycle generator has two main advantages. The design is simple and light, and the unit supplies its own cooling.

With the development of a 24,000-rpm 400-cps aircraft generator came the capability of putting the generator and turbine on a single shaft and common set of bearings. The exhaust of the turbine is cooler than the inlet air. This cool air is passed over the generator and through a ram air heat exchanger. Finally, the exhaust air is discharged rearward to make use of its remaining energy.

The ram air heat exchanger is used for speeds of Mach 4.5 and altitudes from 60,000 to 100,000 ft. A minimum electrical load must be maintained since there is little or no temperature drop across the turbine under no-load conditions. Thus, the generator, exposed to excessive temperatures, would burn out.

In the unit designed by General Electric, a partial arc admission was used. This matches the inlet airflow with the load demands of the generator. It was chosen over a variable inlet nozzle because of light weight and simplicity, and because it allowed a frangible bucket design. This bucket design is important as it is an automatic overspeed control. The buckets fly off if the unit overspeeds, thus, the very part that is causing the overspeed condition is destroyed.

Ram air will usually supply the needed power at Mach 1.5 and above. Up to this speed, bleed air from the engine is ducted to GE's Turbonator. At Mach 3 and above, the bleed air can not be used because of its high temperatures.

The temperature limit for the unit is independent of hydraulic fluids or lubricants if an air bearing is used. The design of the air bearing in the Turbonator calls for turbine inlet air to be ducted through small holes around the journal. The journal is coated with a material similar to brake lining to accommodate momentary rubbing. Development is still needed to improve the low damping characteristics of the bearing, especially under the high external acceleration loads projected for future aircraft. The thrust loads are taken up by a second air bearing, which uses the turbine wheel blank face as one of the surfaces. For comparison purposes, the second radial bearing is an encapsulated oil-lubricated ball bearing.

A cross-section of the Turbonator and a graph of its operating range are shown in Figs. 3 and 4.

### New Materials for CSD

Two limiting conditions on this type of CSD are no electrical load when ram air is hotter than the generator can withstand, and extremely high overloads

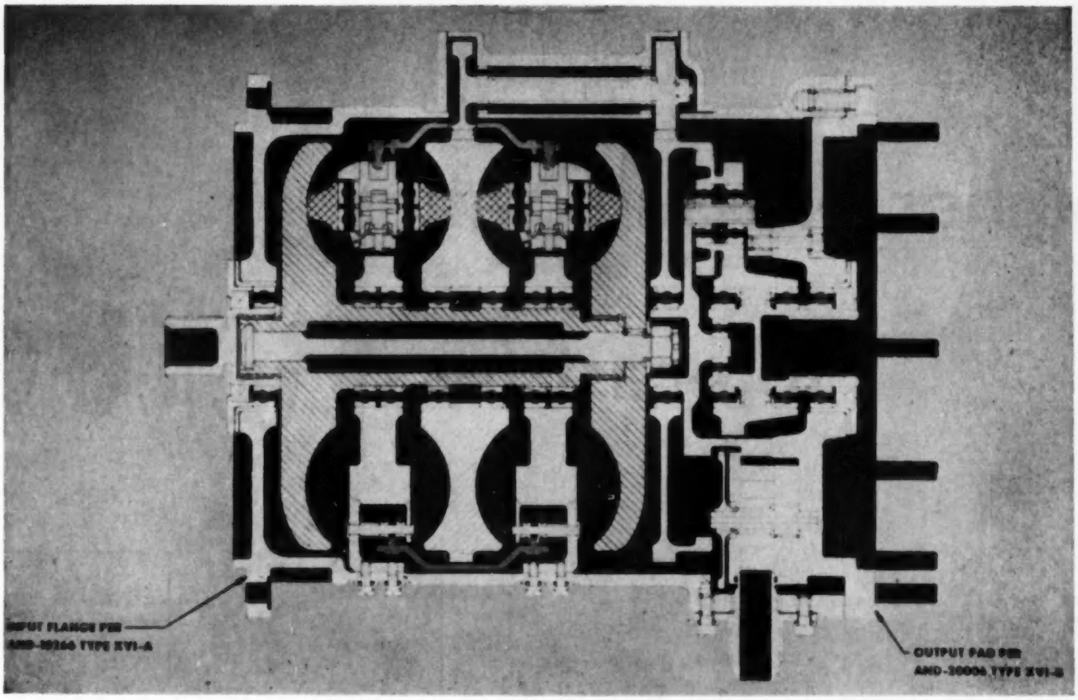



Fig. 5 — Small bearing loads are a feature of the mechanical CSD shown. This means it is almost perfectly tailored to the characteristics of a chlorinated silicone fluid. Such a fluid will give thermal stability, adequate cooling, and lubrication without having excessive extreme-pressure lubricity. Thus, the power transfer through the toroids by friction will not be impaired.

(400%) during idle letdown. In the latter case, the drive does not have the large rotating mass of the jet engine as a momentary source of power.

### Mechanical CSD

A typical cross-section of a mechanical transmission is shown in Fig. 5. The heart of this transmission is the rollers and toroids which transmit power by means of friction at their contact points.

Variable input speed is supplied to the male splined shaft extending from the left end of the housing. This shaft is directly connected to the two toric discs at either end of the major rotating group and causes these discs to rotate at the varying input speed. Power is transmitted through the rollers to the center toric disc, then to the lay shaft, and eventually to the output via a planetary gear set. The planetary gear set is not a necessary part of the drive. It merely steps the output speed up or down to obtain a more satisfactory relationship between the output speed and the input speed range.

The roller toroid "sandwich" is squeezed together by means of a load bolt running through the center. This creates the friction necessary at the roller toroid interface to carry the required load.

The rollers themselves rotate about an axis established by the roller carrier in the plane of the cross-section. The carrier in turn is anchored to the CSD housing and is constrained from rotating.

The ratio changing necessary for the maintenance of a constant output speed is accomplished by rotating the rollers about an axis normal to the plane of the cross-section. In the position shown, the output (center) toroid will rotate at the same speed but in the opposite direction as the input toroid. In effect, this is the "straight through" position. If the input speed is less than the desired output speed, the roller tilts to a new position wherein the roller contact point with the input toroid is farther from the axis of rotation of the rotating group, and output roller-toroid contact point is closer. In this way, the output toroid speed is increased with respect to the input toroid, and the desired constant output speed is maintained. For high input speeds, the roller pivots in the opposite direction.

The rollers are not compelled to move by "brute force" but are steered to a new position. A control ring, powered by error signals from the electronic output speed control, encircles the rotating group inside the housing. Bullet nosed pins extending from the control ring engage cam slots on the roller axles. These cause the rollers to tilt (steer) about an axis in the plane of the cross-section in response to an error signal. The steering action sets up unbalanced couples which cause the rollers to precess about an axis normal to the plane of the cross-section to a new ratio position.

# higher pressure ratios forecast for Turbo

Based on paper by
**J. E. Mitchell**
Caterpillar Tractor Co.

AFTERCOOLING, coupled with higher-pressure turbocharging can increase vehicle engine output. It is no longer day-dreaming to anticipate diesel engines being run with compressors supplying air at pressure ratios higher than 2 to 1.

In the diesel industry at present, the turbocharger with a pressure ratio capacity of about 2 to 1 is just about the standard package for use on small and medium size 4-cycle engines. Fig. 1 shows the capabilities of such a turbocharger relating the ratio of air density increase across the compressor to its pressure ratio, efficiency, and discharge air temperature, all for 90 F ambient air.

Since the engine's output is dependent upon weight rather than volume of air supplied, the density ratio shown in Fig. 1 is the most important consideration. In turn, the density ratio is dependent upon compressor efficiency as well as pressure ratio, for, as shown, an improvement in compressor efficiency from 60% to 80% at a pressure ratio of 2 to 1 produces a 6% higher density ratio and potentially 6% more air for the engine.

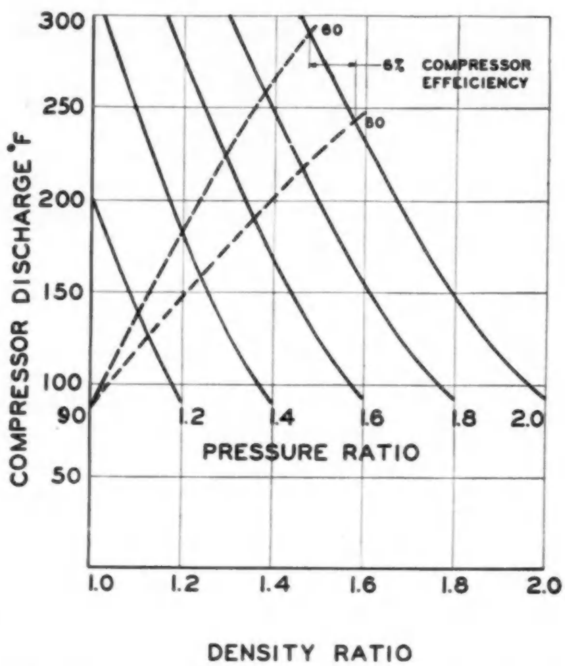



Fig. 1 — Compressor pressure ratio and efficiency effect on density ratio.

## aftercooling

Because the density of the compressed air is dependent upon its temperature at any pressure level, cooling the air after compression to a pressure ratio of 2 to 1 results in the density increases shown in Fig. 2.

Fig. 2 shows curves based on a compressor efficiency of 75%, with aftercoling of the compressed air to 200 F, 150 F, and 100 F. Air densities after such cooling are 7%, 16%, and 26% higher respectively with potentially a proportionate increase in engine air supply. Thus there is good reason to consider aftercooling with turbochargers presently in service.

## higher pressure ratios

Diesel engines may soon be run with compressors supplying air at pressure ratios higher than 2 to 1.

Expansion of the density, pressure, and temperature considerations to higher pressures are shown in Fig. 3. Here again a 75%-efficient compressor was used with cooling after compression to 200 F, 150 F,

# chargers

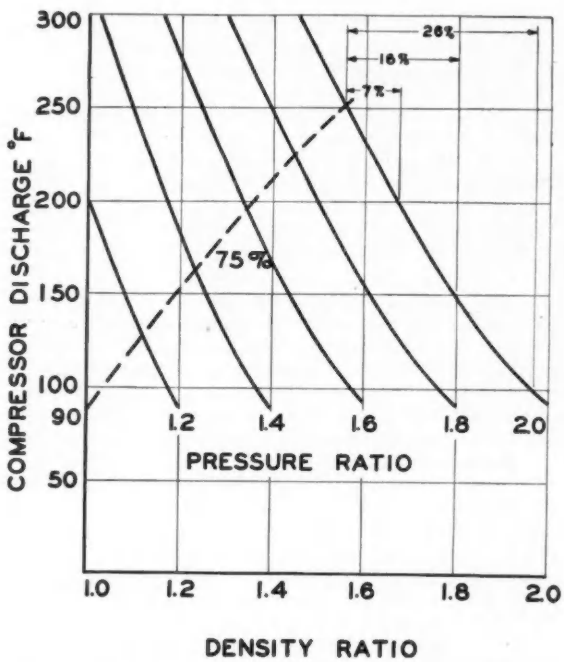



Fig. 2 — Aftercooling effect on density ratio for medium pressure turbocharger.

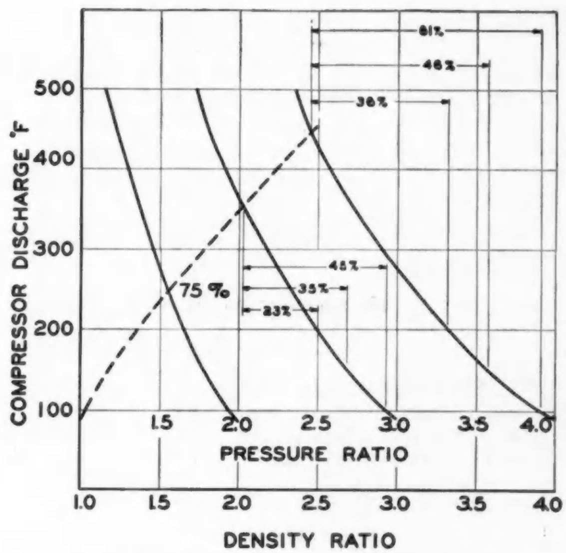



Fig. 3 — Aftercooling effect on density ratio for high pressure turbocharger.

and 100 F. At a pressure ratio of 3 to 1 the increase in density ratio by use of aftercooling to these temperatures is 23%, 35%, and 45% respectively compared to the density ratio at 3 to 1 pressure ratio with no cooling.

A more reasonable consideration from an engine operational standpoint would be to compare the increase in density ratio of the high pressure ratio air with aftercooling, to lower pressure air without aftercooling. Use of the high pressure is generally contingent upon use of aftercooling to avoid high air to engine temperature which would result in a relatively small increase in air supply achieved by a large increase in engine system temperature and pressure.

For example, consider the density ratio of 1.55 achieved at a 2 to 1 pressure ratio without aftercooling as a base point. Use of a 3 to 1 pressure ratio machine with aftercooling to 200 F, 150 F, and 100 F will increase the density ratio to 2.50, 2.68, and 2.94. These reflect percentage increases in density ratio of 61%, 73%, and 90% which are substantial gains. The increases attainable at a 4 to 1 pressure ratio are even greater as shown in Fig. 3.

**To Order Paper No. 103A . . .**
. . . on which this article is based, turn to page 6.

# 4 New Methods for

# Shaping New Materials

## 1. Electrical Discharge Machining

## 2. Ultra High Speed Machining

## 3. Chem-Mill Process

## 4. Abrasive Belt Machining

Based on report by secretary **R. R. Dobson**
Ryan Aeronautical Co.

**NEW METAL REMOVAL TECHNIQUES** are shaping high strength and heat-resistant materials faster, more economically, and to closer tolerances. Here are descriptions of four methods which are receiving greater and greater acceptance by industry.

### electrical discharge machining

Electrical discharge machining is accomplished by a series of discharges (20,000–300,000 per sec) between the tool (electrode) and the workpiece.

By gradually increasing the voltage between the electrode and the workpiece a single discharge of billions of electrons is created. The electrons pile up on the electrode until the stress is so great that they break through the surface barrier and strike the surface of the workpiece at tremendous speed. This force removes electrons from the atoms of the workpiece resulting in a net positive charge. The positive charged particles are then drawn back toward the negative electrode. But as they begin to move they are cooled by a dielectric fluid and are washed out of the gap between electrode and workpiece before they reach the electrode.

The power cycle in this process is of such short duration that only metal removed is heated, thus preventing any appreciable heating of the balance of the workpiece.

The dielectric fluid serves both as a coolant and as a flush for removing the minute metal particles as they are eroded from the workpiece. Both the workpiece and the electrode are completely submerged in the dielectric fluid during the machining operation. A circulating pump and filter system removes metallic particles and other foreign matter generated during the machining operation.

Electrical discharge machining is of particular advantage in producing holes and cavities of various geometric shapes to tolerances of $\pm 0.0005$ in. Holes as small as 0.002 in. diameter have been successfully drilled through $\frac{3}{8}$ in. steel plate with no distortion. The process has no detrimental effect on either microstructure or impact properties and creates no stress or warpage in the part being machined. Surface finishes in the order of 10–20 microinches can be easily produced without scratches, heat checks, waviness, or chatter.

Electrical discharge machining is applicable to any conductive material, and is particularly advantageous with the newer, harder, and higher temperature-resistant materials. In most cases these materials which range from difficult to nearly impossible to machine by conventional methods can be economically handled by this process.

### ultra high speed machining

Of the major factors influencing the cost of machining operations, the one factor which has the greatest potential for reducing costs is SPEED.

With present facilities and practices, machining speeds are limited to about 350 sfpm with the annealed titanium alloys and hardenable steels. This is reduced to 150 sfpm after hardening. In contrast, the aluminum alloys are cut at speeds up to 15,000 sfpm, which is considered to be high at present. However, tests are now under way to investigate cutting speeds up to 250,000 sfpm on thermal-resistant alloys.

Machine cutting operations depend upon plastic deformation and brittle rupture to some degree. Plastic deformation is accompanied by shear plane slippage while rupture is a crystalline phenomena. Some theories propose that cleavage failures are an elastic wave phenomena traveling at speeds of about one-third the speed of sound in that material. Shear failures are proposed as traveling at a much slower speed. Normal machining speeds cause the material ahead of the tool to be deformed by shear and compression forces, with the chip crushed by compression. By applying the theory of brittle cleavage failures to machining operations, it is proposed that the speeds be increased to the point where brittle cleavage will be continuous. This speed would be high enough to permit complete cutting before plastic shear-plane deformation could take place. This would eliminate the cause of high cutting temperatures and the high power requirements of lower speeds. And this also would enable thermal-resistant, high-strength materials to be machined in the hardened condition with smoother, more uniform surfaces in much less time.

Preliminary tests of these theories, using a linear-motion testing device, disclosed cutting speeds up to 150,000 sfpm without cutter failure. In addition surface finishes as smooth as 15 microinches were obtained and a hardness increase of 1–4 points on the Rockwell C scale (from 0.004–0.010 in. below the machined surface) was noted.

Should further tests prove that hardened thermal-resistant steel can be machined at 150,000 sfpm with unlimited tool life, it is conceivable that some types of machining operations can be adapted with little development, while other operations may never be reduced to practice. Several approaches are possible. Single-action rotary motion such as in milling or turning must be examined closely as the bursting effect at ultra-high speeds becomes very large. Combinations of rotary motion with the tool and part counter-rotating could produce an effective cutting speed of very high magnitude. Linear motions such as those produced by explosives could produce ultra-high speeds for broach-like applications. (Normally explosives are not used in production but even now some forming operations are using this method regularly at a cost saving over press work.)

## chem-mill process

The ability of the chem-mill etchant to remove metal is affected primarily by the chemical composition of the metal and essentially unaffected by physical characteristics such as hardness. This, in conjunction with the ability to readily remove metal from formed parts, makes the chem-mill process an important factor in present and future airframe design.

Chem-mill is presently applicable to sheet, plate, extrusions, forgings, and in many cases, castings, and can be used to advantage in the following applications:

1. Etching, after forming, of complex patterns on parts of simple or compound curvatures.
2. Overall weight reduction of complex shapes such as forgings or extrusions.
3. Multiple step designs, or web thicknesses, on small or large areas of one sheet can be accomplished.
4. Very thin final cross-sections can be obtained without inducing mechanical distortion of the remaining web.
5. Materials with low machineability factors or parts difficult to hold for machine milling can be readily chemically milled.
6. Simple or compound tapers can be readily achieved.
7. Sheets may be etched from both sides simultaneously, shortening the processing cycle and minimizing warpage.
8. Improved strength-to-weight ratios can be obtained.
9. Tolerances of $\pm 0.002$ in. etch depth plus the actual stock tolerances are applicable to most chem-mill designs.

The specific design of any particular part is the governing factor in the selection of the most economical fabrication process. Simple patterns and deep cuts can generally be machined economically, while parts with complex patterns can usually be produced more economically by the chem-mill process.

Some of the economical production characteristics of chem-mill include, low rejection rates because of close tolerance control and fewer operations. Additional surface treatment is virtually eliminated. Tank dimension is the only limitation to the number of parts that may be milled at one time. A large number of parts or designs may be milled at one time on a single sheet. The process is economically favorable for fabrication of prototypes for design and structural studies because of inexpensive tooling.

The chem-mill process consists of five main steps: cleaning, masking, layout, etching, and mask removal. The efficiency of the process will be enhanced in proportion to the efficiency of related factors. These factors include adequate parts handling, automatic operation where practical, chemical control, thermostatic control of baths, and recovery and disposal of by-products.

The chem-mill processes for titanium and steel alloys are more complex than the aluminum process. The increased complexity is related to the type and number of active ingredients required in the etchant formulations and the exothermic heats of reaction. Problems are also encountered in the selection and design of facility and process equipment resistant to the solutions.

Etching techniques for ferritic steels, and low and high-alloy steels have been developed. However, because of the wide range of compositions of steel alloys, it is not possible to etch all under the same bath conditions. A wide variety of steel alloys

# 4 New Methods for Shaping New Materials

. . . continued

may be milled by varying concentrations of the etchant ingredients without changing the basic etchant compositions or temperature. Generally, the ferritic and heat-treated steels have slightly rougher surfaces and require more critical etchant control than alloy or annealed steels.

Etchant techniques applicable to a variety of titanium alloys have also been developed. Because of less variance in alloy composition and reactivity, control of the etchant composition for the various alloys has not been as complex as for steel.

### machining with coated abrasive belts

The acute need for close tolerances in skin sizing is indicated by the fact that an increase in sheet thickness of only 0.001 in. will increase the weight of some proposed airframes by as much as a ton. The increased use of brazed honeycomb sandwich in aircraft presents another close tolerance requirement. This requirement can be satisfied by the use of abrasive belt grinding.

One of the methods currently being used is the Farnham 7 ft × 40 ft abrasive belt grinder. This machine is capable of grinding large plate and sheet stock up to 86 in. wide by 40 ft long to tolerances of ± 0.0015 in. It may also be used for honeycomb.

Belt speeds are approximately 4500 sfpm with a feed of 18 fpm for stainless steel honeycomb. As much as ¼ in. has been removed per pass on heat-treated core. The belts are 180–220 grit, aluminum oxide, closed coat, waterproof cloth, and can be removed and installed in about 5 min by one man.

Probably the most economical abrasive belt machining technique for producing flat and parallel honeycomb details to tolerance requirements is the Curtis conveyor-type abrasive belt machine. Special hold-down methods are eliminated by use of this equipment and burring is minimized. Core thickness tolerance is maintained by a dynamically balanced contact roller of steel.

Equipment of this basic type is now under development, primarily for mild double-contoured honeycomb parts. Flats and tapers may also be ma-

## New testing techniques answer question . . .

# When Is a Tolerance

Based on paper by

**Dorian Shainin**

Director of Statistical Engineering, Rath & Strong, Inc.
(Reported by R. S. Karlson, SAE Southern New England Section Field Editor)

SPECIFICATIONS that are realistic for production and result in a product that functions properly can be set with a 3-step method evolved from statistical control techniques. The tolerances thus established reduce production costs as well as costs arising from faulty products.

Table 1 outlines the three steps, the procedures to be followed, and the number of test units required. In the first step, two units are disassembled and then reassembled with two components interchanged from each unit. The components can be single parts or subassemblies, depending on the complexity of the unit. And the units selected for test should be those having the widest permissible variation in performance so that interchange will reveal the parts responsible for the variation. The units with parts interchanged are tested with a chart of random numbers so that different units are tested at random times and in random order, thus avoiding a set pattern.

### how the interchanging is done

The tool for analytical testing is the Latin Square, shown set up in Table 2. The parts are interchanged according to the pattern in the Square which allows four new units to be assembled. When test results are checked for eight or more combinations, taken by means of random numbers, averaging the vertical differences in performance between the interchanged assemblies will cause the *S* and *R* components to cancel each other out. This gives the variation in performance caused by the real difference between parts *C* only, except for slight varia-

chined here. A drum cam forces the grinding belt to the desired contour. The drum cam is indexed to the table and rotates at the same speed as the table travels. The cam presents a constantly changing contour as it rotates. It is anticipated that close-out members and core will be ground to final finish at the same time, thus assuring the coordination necessary for a successful braze.

Exceptional tooling coordination can also be attained with this equipment, since stretch-press dies and braze fixtures can also be finished. This is accomplished by turning the belt inside out and grinding the cam, using a master as a basis. The belt is then returned to its normal condition and, using the cam as a basis, the core or stretch-press die is finish machined. Equipment of this type appears to be the answer to meeting production needs for machining double-contoured honeycomb core.

Another application of abrasive belt machining now under development is that of sizing close-out members for brazed honeycomb assemblies. This is especially important since it is almost impossible to form close-out details to the required ± 0.0015 in. tolerance by either hot or cold forming means. With this method the final few thousandths can be removed to bring the details within brazing tolerance requirements. This method is adaptable to close-out members for constant thickness honeycomb panels, contoured or flat.

Generally speaking it can be seen that the abrasive belt machining method will result in high removal rates, accuracy, and reduced distortion. It has also proved to be an efficient metal removal method for many other applications, such as deburring and specialized cleanup. Additional applications will be found dependent only upon the ingenuity of the manufacturer and designer. Based upon future need, abrasive belt machining is only in its infancy.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: **D. S. Whetstine**, Ryan Aeronautical Co.; **C. L. Calvert**, Ryan Aeronautical Co.; **W. F. Wagner**, Northrop Aircraft, Inc.; **K. Sparling**, Lockheed Aircraft, Inc.; **M. Sanz**, North American Aviation, Inc.; **M. M. Gilman**, North American Aviation, Inc.; **A. E. Salen**, Northrop Aircraft, Inc.; and **Col. R. L. Hill**, USAF, Air Material Command.

(This article is based on a secretary's report of a production panel entitled "Metal Removal — High Temperature Material." This report — along with 10 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-325. See order blank on page 6.)

# Just Right?

tions which might be due to lack of repeatability. The effect of this lack can be eliminated by repeated tests and use of a Table of Odds.

Averaging in the horizontal direction gives the difference which shows the effect of variances in component *S* unaffected by parts *R* or *C*. Then, by averaging diagonally, differences are determined which are independent of *C* and *S* and show the effect of *R* on the variance in output.

Step 1, then, reveals the effect of two parts on overall output. By interchanging other parts or subassemblies, the exact effect of all components can be determined. This makes it possible to establish the beginnings of a required specification and allowable tolerances for the various parts of an assembly.

## multi-vari chart as a tool

In the early stages of production, say after nine assemblies have been made, additional changes can be detected which will further reduce variations in outputs. The analytical tool used in this second step is the Multi-Vari chart, which will show variations between units graphically. Here, for the first time, it is possible to estimate how much of the total variation is associated separately with each of three parts of total variation: (1) within the assembly (lack of repeatability), (2) assembly to successively built assembly and, (3) time to time. Latin Squares are used as needed to determine what individual parts are causing variation. The objective of this step is to reduce the two largest of the three parts of total variability coming from manufacture so that they approximate the variability of the smallest.

## random balance analysis

The third step, the Random Balance Analysis, is made after about 30 units have been produced. The various subassemblies and the required output of each are listed and each part is checked against its own respective tolerances. Tests are made on each unit and variances in output corresponding to tolerances of the part are recorded. If output varies excessively, parts are compared to determine the cause. Here, again, a chart of random numbers is used in running tests to avoid following a pattern. For satisfactory results, the parts under test should use at least 70% of the allowable output tolerance. If necessary, components can be interchanged so that most of the overall tolerance is used. This will give a good picture of what will happen if larger produc-

## New testing techniques answer questions . . .

# When Is a Tolerance Just Right?

. . . continued

tion is undertaken. Plots are made of test results versus assembly numbers to be certain no trend is followed by the units during production.

This series of tests will show some parts and subassemblies to have more effect on the overall output than others. The information can be used to set up tolerances which hold important items to required limits and allow unimportant items to have more variation.

Using the parts themselves to determine what tolerances can be held and what important ones must be held lowers the cost of assembly, steps up production and, generally speaking, results in a better product.

### putting the method to work

To show how Step 1 of this method can be used to reduce variation in output, the case may be cited of two seemingly identical mechanical-hydraulic units having specifications which called for no external leakage. Both units leaked slightly at the cover O-ring seal. A gradual wetting of the joint between cover and body was noticeable after operation for 10 min on the test rig.

A thin bluing check showed the body and cover faces of both units to be flat and smooth. The seal diameters and the width of the seal groove in the cover were measured and found to be within specification. Although the widest permissible groove width and the smallest seal diameter on the drawing board showed an adequate interference fit, the conventional engineering approach was to increase the nominal seal diameter or reduce the groove width in the cover.

The statistical engineer on this job set out to find a way of measuring the amount of leakage, although only two units were available. He cut equal size rectangles from a sheet of blotting paper. A single drop of oil was deposited on a metal surface from an eye dropper. The short side of the rectangle soaked up the drop of oil, discoloring the paper for a certain distance from that side. The test was repeated for another drop using a piece cut from a location on the large sheet away from the first. The soak distance was the same.

One rectangle was applied to each unit and allowed to soak up the leak for 10 min. The units differed; one leaked a drop and a half, the other leaked three drops.

### application of the latin square

At this point the Latin Square was used to isolate the component responsible for most of the difference in leakage. The 3-drop unit was labeled *HI*, and the other *LO*. The cover was designated *C*, the seal *S*, and the rest of the unit, the body assembly, *R*. Four assembly combinations from these components of the two assemblies were drawn up as shown in Table 2.

Each of the four combinations indicated in the diagram was put together twice, in random sequence as shown by the numbers at the right of each box. The leakage taking place in 10 min in the eight trials was:

| Test | Combination | Drops in 10 min |
|---|---|---|
| 1 | $C_{HI}S_{LO}R_{LO}$ | 3.2 |
| 2 | $C_{LO}S_{HI}R_{LO}$ | 1.7 |
| 3 | $C_{LO}S_{LO}R_{HI}$ | 1.8 |
| 4 | $C_{HI}S_{HI}R_{HI}$ | 3.2 |
| 5 | $C_{HI}S_{HI}R_{HI}$ | 3.0 |
| 6 | $C_{LO}S_{HI}R_{LO}$ | 1.4 |
| 7 | $C_{LO}S_{LO}R_{HI}$ | 1.6 |
| 8 | $C_{HI}S_{LO}R_{LO}$ | 2.9 |

Averaging the leakages in their proper positions in the Latin Square gives:

| | |
|---|---|
| 1.6 | 3.2 |
| 1.8 | 2.9 |
| 1.7 | 3.0 |
| 1.4 | 3.2 |

The use of a random sequence has forced, with a high probability, all other factors which also could affect leakage to show their net effect in the lack of repeatability between the pairs of trials of exactly

### Table 1 — Outline of 3-Step Test Method

| Objective | Products Needed | Analytical Tool |
|---|---|---|
| 1. Reduce number of components contributing to excessive output variation. | Two or more experimental units. | Latin Square — Interchange of components. |
| 2. Equalize points of total manufacturing variance. | Nine early production units, preferably three groups of three units each with time interval in between. | Multi-Vari Chart — To show graphically variations between units. |
| 3. Evaluate and change tolerances for setting up a practical and realistic set of specifications. | A few sets of components from 30 early production units. | Random Balance Analysis — To separate effect of each tolerance on overall performance. |

the same combination of components. Some of these factors would be the method of assembly, temperature of oil, influence of humidity difference on the blotting paper, variation in the skill of the engineer in touching all spots to pick up oil with the blotter. Such factors can change with time. If each combination is done again at some random, later time, the influence of the factors can be measured. But if the testing were done in systematic rather than random order, some factors changing with time would have their effect confounded with the effect of one or more of the components. For example, in systematic order the last four tests could have been the ones giving the higher leakages, close to three drops per 10 min. And the real cause could have been the test rig temperature stabilizing at some much higher value than it had during the first four runs. But because they all used $C_{HI}$, the higher leakages would have been associated with that cover.

### much information from a limited source

The average of the difference between the pairs of results is 0.25 of a drop, properly called experimental error only from a randomized experiment. This measure of the effect of all other factors can be used for comparison with the separate effects of the difference between the two covers, the two seals, and the two body assemblies. Hence, much information can be obtained statistically from only four combinations.

The vertical average of the four readings under $C_{LO}$ 1.6 can properly be compared with the average under $C_{HI}$ 3.1. The influence of any difference between the two seals has been neutralized here, since two of the readings under $C_{LO}$ were with $S_{LO}$ and the other two were with $S_{HI}$. Similarly, in the $C_{HI}$ column are two contributions each from $S_{LO}$ and $S_{HI}$. Whatever the effect of $S$, it does the same thing to each of the vertical averages, because the contribution is similar. Since the difference between those two averages cannot be influenced by $S$, it represents the influence of $C$. The rest of the unit $R$ is similarly balanced out or neutralized. And a statistical table of odds will give the chances that the lack of repeatability 0.25 can explain the 1.5 difference between the averages for $C_{LO}$ and $C_{HI}$. Since these odds are low it is an intelligent engineering decision that a valid cause-and-effect relationship probably is being shown by this statistically designed approach.

The difference between the horizontal averages 2.4 and 2.5 for $S$ cannot be affected by the balanced-out influence of $C$ and $R$. And the diagonal averages show the effect of the rest of the assembly $R$ to be 2.3 and 2.4 with $S$ and $C$ neutralized. So 1.5 clearly predominates over the other two differences, 0.1 and 0.1. The statistical table shows the odds to be high that the 0.1 differences could have come entirely from lack of repeatability, meaning that $S$ and $R$ could have no effect whatever on leakage.

### cover revealed as culprit

The two covers were inspected carefully, both visually and dimensionally, to detect the quality characteristic causing the leakage difference. When nothing could be found and when the leakage, using $C_{HI}$, did not diminish after the cast cover had been impregnated to seal whatever fine porosity there might be, several engineers wanted to try seals of different diameter and different durometer hardness. The statistical engineer, however, insisted the leakage must be due to some difference between the covers, the experiment having eliminated the body and the seal.

One engineer though it illogical for the anodizing to cause leakage. Another engineer looked in the groove for the seal and remarked that the anodic coating had not been masked from the groove. But he, too, thought it inconsequential. A third engineer remarked that some coatings seemed rougher than others; perhaps the coating itself was porous. The coating was removed from the groove of $C_{HI}$ to expose the bare metal and the leaking stopped. $C_{LO}$ also stopped leaking when cleaned. The specification requirement that there be no external leakage had become a reality.

Other outputs, such as gallons per hour delivery and change in flow with application of a given back pressure, were checked in the two experimental units with Latin Squares consisting of the relief valve subassembly, the pump subassembly, and again $R$ for the remainder of the unit. One by one the approach gave basic factual information leading to the early reduction of output variation.

**Table 2 — Organization of Latin Square**

| | $C_{LO}$ | | $C_{HI}$ | |
|---|---|---|---|---|
| $S_{LO}$ | $R_{HI}$ | 7<br>3 | $R_{LO}$ | 1<br>8 |
| $S_{HI}$ | $R_{LO}$ | 2<br>6 | $R_{HI}$ | 5<br>4 |

$C_{LO}$, $C_{HI}$ — Part C from low and high assemblies.
$S_{LO}$, $S_{HI}$ — Part S from low and high assemblies.
$R_{LO}$, $R_{HI}$ — Remaining parts of low and high assemblies.

**To Order Paper No. S125 . . .**
. . . on which this article is based, turn to page 6.

## Proposed Constitution amendments are being balloted on by entire membership as result of Annual Business Session action

At the Annual Business Meeting, held as part of 1959 SAE Annual Meeting, it was voted to submit to the membership for mail ballot the proposed amendments to the SAE Constitution by which the Planning for Progress program would be brought into active operation.

This important action was the feature of a week which spotlighted 30 technical sessions. Eighty-seven technical papers, an all-time high for an SAE meeting, covered topics ranging from Structural Glass in Cars to Control of Exhaust Gas Emissions. Capsule descriptions of all 30 sessions begin on this page.


A. O. Willey

The 1959 SAE Council, at its first meeting on Jan. 16, elected A. O. Willey to be a Councilor for the year 1959. The vacancy on the 1959 Council was caused by resignation of Leonard Raymond at the end of the first year of his two-year term as Councilor in order to become 1959 President of the Society.

Registration at the Sheraton-Cadillac and the Hotel Statler sessions totalled slightly above those for the 1958 Annual Meeting. The large Friday afternoon session — at which the industry's latest work on control of exhaust gas pollution were presented — put the meeting total up.

### Displays Popular

Well-attended throughout the week were the 84 booths and 5 parlors forming the Engineering Display. Informative displays and exhibits covered almost every phase of automotive engineering interests. R. H. Isbrandt, American Motors' director of automotive engineering, was chairman of this year's Engineering Display Committee.

### Dinner Speaker Delayed

Scheduled Dinner Speaker T. Keith Glennan, administrator of the National Aeronautics and Space Administration, was prevented by weather conditions from reaching the dinner in time to present his address. R. W. Young, president of Reaction Motors, read Glennan's paper, in which the Administrator emphasized:

"I do not share the conviction held by some of my friends that the Soviet Union is far ahead of us in space.... Unless I miss my guess by a wide margin," he predicted, "we are all going to be surprised by the record a year from now — and pleasantly surprised."

### Capsules of Technical Papers

**V-Type Diesels** — Two new series of diesels have been added to the Detroit Diesel line: the smaller 53 Series (which contains one V engine) and the V-71 Series (which, as its name implies, is all V engines).

The V configuration was chosen for all the new engines (except the very small 2-, 3-, and 4-cyl 53 Series) because of its inherent size

**ENGINEERS FROM OVERSEAS** will be invited by SAE's Overseas Information Committee (above) to present a series of technical papers at the 1959 SAE Summer Meeting in Atlantic City next June. OIC Chairman M. A. Thorne is seated in the center of the group. (From left to right): Paul A. Miller, M. F. Garwood, Thorne, C. G. A. Rosen, and J. T. Dyment

# sae annual meeting

and weight saving characteristics. For example, the new 6V-71 engine is 40% shorter and 15% lighter than the in-line 6-71 engine.

Three main ground rules were laid down for the design of the new engines: maximum fuel economy at conservative ratings; maximum use of standard parts, particularly those of higher service usage; and minimum weight and space per horsepower.

**Engine for Mechanical Refrigeration** — The Witte Series 100 diesel engine was developed to furnish power for mechanical refrigeration on railroad cars. The engine is of 4-in. bore, 4-in. stroke, and rated at 18 hp at 1800 rpm for continuous duty. Its horizontally opposed, 2-cyl design provides unusually smooth operating characteristics, due to the inherent balancing of reciprocating masses, as well as a low center of gravity to resist the shock of railroad operations. It uses a 4-stroke cycle with precombustion chambers and pintle-type nozzles, all of which contribute to its preference for No. 2 diesel fuel.

**Nuclear Planes and Parts** — Fundamental tests are building a warehouse of information on nuclear-designed aircraft parts. Already a preamplifier is operating at 500 C with a radiation dosage of $1.5 \times 10$ neutrons per sq cm — and a nuclear reactor has been flown.

In both cases the purpose is to prove materials and techniques under investigation. The preamplifier uses platinum wires and gold connections and the reactor wasn't used to power the airplane. But the results of flight and ground experiments have proved methods of calculating shielding designs to an accuracy of 15% — and substitute materials will be found for the preamplifier before it is put into production.

**Diesel Smoke** — Diesel exhaust smoke is a problem for equipment operators, engine builders, and fuel suppliers because it contributes to air pollution and is apparent and objectionable to the public. There are three kinds: black, white, and blue. Black smoke is affected little by fuel quality. White occurs primarily when the engine is cold. Blue smoke occurs only in some engines and is heaviest at medium load; it is affected by certain components in diesel fuel.

The amount of these components has more effect than normal variations in engine condition, and none of a number of fuel additives tested offset smoke.

Smoke-producing components are not yet specifically identified but their concentration is related to fuel volatility and composition. Further work to identify the components and find ways to burn them or remove them from fuels is necessary if diesels are to continue to operate on economical fuels and yet emit clean exhaust.

**Diesel Performance Analysis** — Computer studies show that four-way division of the exhaust of a V-8 diesel provides good matching of a turbocharger to the engine. This arrangement reduces the increase in turbocharger pressure ratio usually experienced with increase in engine rpm. The lower pressure ratio is reflected in a lower peak cylinder pressure.

A practical four-way division allows the use of two turbochargers with a two-way divided turbine housing (one on each side of the engine) or a single four-way divided turbocharger. The cylinders from each bank are paired such that a minimum of two other cylinders fire between the cylinders of each pair. This arrangement reduces the effect of one cylinder upon the scavenging of another and is recommended where a four-way division of exhaust is desired.

**High-Temperature Materials** — Special coatings are one way that the properties of metals are being protected against ever-increasing temperatures. Ceramic coatings are used to bond solid lubricants such as graphite and lead oxide to surfaces sliding at 1000 F. Similar coatings of aluminum and zirconia protect metals from corrosion and provide thermal insulation. Flame spraying is used to deposit the coatings. Extensions of this technique are expected to apply coatings that will withstand 5000–6000 F. Rocket engine parts also need coatings to make them compatible with strong liquid oxidizers like nitrogen tetroxide. This oxidizer will strip cadmium off steel, anodizing off aluminum and soften Kel-F seals — all in a couple of hours.

**Ground Support Equipment** — The missile can now be considered the simplest and cheapest part of a long-range weapons system. A fleet of vehicles, stuffed with electronic equipment, is needed to fire one missile — and maintenance of the support equipment is greater

than the maintenance of the missile.

At the same time the support equipment for aircraft and missiles has become one to two orders of magnitude more precise, compared to World War II standards.

**Fuels for Ground Vehicles** — Improved laboratory tests are being devised to aid in the development of better fuels. For example:

1. Laboratory methods of evaluating carburetor icing field performance have been developed. From this program it appears that: (1) The range of weather conditions affecting carburetor icing severity is the combined effect of temperature, evaporative cooling, and absolute moisture content of the atmosphere. (2) The entire ASTM distillation range affects the carburetor icing tendency of a given gasoline. (3) Synergistic qualities of additives with respect to anti-icing quality have been discovered.

2. The chassis dynamometer plus magnetic tape for automatic control of throttle position and braking can show the relative effects of changes in gasoline volatility on passenger-car engine warmup. In addition, a strip chart recorder is used to produce a trace of engine speed and choke performance. From this, the warmup point, or distance traveled to obtain smooth operation after a cold start, can be obtained. It appears that the chassis dynamometer tests are more reproducible than road tests. Reproducibility of tests in terms of miles to warmup was 0.4 on the chassis dynamometer, as compared to 0.6 on the road. The automatic instrumentation used in the tests also reduced manpower requirements necessary to conduct such tests and provided efficient, around-the-clock testing, regardless of weather conditions.

3. Radioactive tracers have been used to study the fuel distribution among individual cylinders in V-8 engines. Individual fuel components (both hydrocarbons and fuel additives) were tagged with radioactive hydrogen (tritium) or carbon-14. These tagged components were blended into a commercial-type fuel, and their distribution to engine cylinders was determined by measurements of exhaust gas radioactivity. The quantity of fuel distributed to the cylinders was measured by an exhaust gas analyzer of the catalytic cell type. In the two engines investigated, distribution was found to be more affected by the position of the throttle plates than by any other operating variable. On one engine, the adverse effects of throttle-blade position were greatly minimized by shifting the throttle-plate axes 90 deg in the horizontal plane. The resulting improved fuel distribution increased power and fuel economy, reduced octane requirement for a given power output, and gave higher tel effectiveness.

An investigation has also been made of the relationship between LPG characteristics and the knock-limited performance of several truck and bus engines over a range of design and operating conditions. This work showed, among other things, that:

- The knock-limited spark advance characteristics of LPG blends in the engines tested could be rationalized in terms of the Research and Motor octane numbers calculated and determined for the blends.
- If carburetor air or mixture temperatures are not controlled to reasonable limits, satisfactory knock-free operation will not be experienced in all heavy-duty engines with pure propane.

**Radioisotope Applications** — There are many advantages to using radioactive tracers in helping to solve research and engineering problems. They can save time, increase accuracy of results, reduce costs, and, in some cases, even allow one to do things that previously could not be done at all. That's why they are finding more and more applications, such as the following:

1. Sulfur-35 and, to a limited extent, carbon-14 are becoming

**LIFE MEMBERSHIP** was presented to SAE Past-President George A. Delaney (right) by 1958 SAE President William K. Creson. Delaney has just completed his 2-year term as Past-President on the SAE Council. The award was made Tuesday evening, January 13, at the Annual Business Session.

important in rubber research. Problems connected with the solubility of sulfur or sulfur-containing compounds in rubber mixtures, migration, and "blooming" or surface crystallizing tendencies, for example, can all be most readily investigated with S-35. Tagged sulfur in an unvulcanized rubber mixture is also the basis for a convenient laboratory method for determining the amount of sulfur that combines chemically with the rubber during vulcanization.

2. Krypton-85, a radioactive gas, is helping to measure pulsating engine airflow. The total-count method, as it is called, gives absolute values with an accuracy of 3% without the need for calibration against standard flows. No restriction of the flow is necessary in the measurement. The method can be used without modification over a wide range of airflows.

3. Gold-198 was used to investigate whether preionizing the spark-plug gap of a high compression ratio engine would reduce the secondary spark discharge voltage requirements. The study showed that no such reduction is realized under normal engine firing conditions. Although radiation produces a substantial voltage reduction at atmospheric pressures and temperatures, it was found that the thermal electrons produced at normal engine operating temperatures and pressures cause sufficient ionization to saturate the spark gap with ions. Thus, no further amount of ionization can be achieved by a radioactive source.

4. Radioactive chromium was used in the top piston rings in engines of a test fleet. In this way it was possible to find out the relative effects of three different fuels on face wear of these rings without interfering with the major purpose of the fleet test program, which was to provide data on octane requirement increase and spark-plug fouling.

**Aviation Lubricants** — Certain esters prepared from a class of highly fluorinated alcohols extended the maximum use (bulk oil) temperature of ester lubricants up to 550 F. But these lubricants did not possess the excellent V.I. and low-temperature properties desired in the 9236 oils. The good lubricity and oxidation resistance of two fluoroalkyl esters predicted by laboratory tests has been confirmed by limited rig and engine testing. Additional field evaluation of these esters will have to be completed before their final usefulness can be established.

**Aviation Hydraulic Fluids** — The selection of the most satisfactory rubberlike material for use with synthetic hydraulic fluids in a particular application depends generally on (1) compatibility with hydraulic fluids, (2) physical properties, and (3) performance and endurance requirements.

Included in these broad categories are problems related to functional environment, such as resistance to heat and aging, low-temperature flexibility, frictional properties, wear and abrasion resistance, as well as problems associated with manufacturing close-tolerance parts.

A knowledge of fluids, polymers, and compounding ingredients is required in choosing base materials for candidate stocks, placing emphasis on compatibility and physical properties. In addition, hardware designers establish functional requirements that must be met by the finished product, and provide valuable test and development information for improvement of future materials.

**Low Flying Platforms** — Forward pitching moment control has been one of the major problems in constructing a low-flying one-or-two-man military vehicle. A solution is to apply thrust control to the multiple vertical fans that support these platforms. Both 2- and 4-fan configurations have been successful.

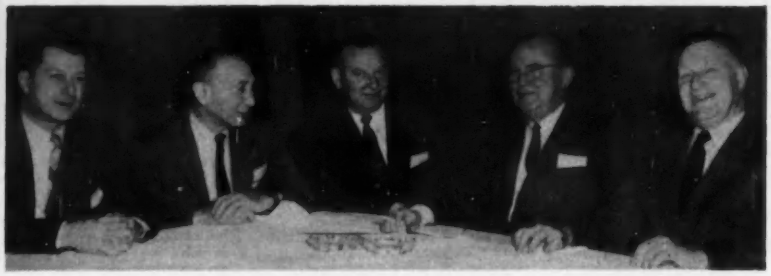
The forward motion of the platform has also compromised the use of ducted fans. While these fans are very efficient for hovering flight, they step up the drag in forward flight and aggravate the pitching moment problem.

**Structural Glass in Cars** — Glass as manufactured today, whether regular (annealed) or automotive safety glass (heat strengthened and laminated), fails to meet the strength properties generally required of structural materials. Factors such as surface abrasion and weathering further reduce the

**CONSTITUTION REVISIONS,** designed to make operative SAE's Planning for Progress program, have been submitted to the Society's membership for mail ballot . . . as a result of the action taken at the Annual Business Session on Tuesday evening, January 13. . . . 1958 SAE President W. K. Creson presided at the Business Session. W. F. Ford, chairman of the Council's Planning for Progress Review Committee, explained that the proposed revisions had already been reviewed with all of the Society's important working groups and with the governing boards of its Sections.

W. K. Creson

W. F. Ford

**REVISED PUBLICATION POLICIES** and operating procedures were detailed and approved at a Publication Committee meeting where 1958 Chairman Leonard Raymond (left) turned the Committee's leadership over to 1959 Chairman T. L. Swansen (right). Other Committeemen at the session were (left to right): R. S. Frank, Emil Gibian, C. A. Lindblom, 1958 SAE President W. K. Creson, and William Littlewood. The Committee also reviewed and approved a long-range financial planning report prepared at the Committee's request by Gibian. (Later this report was presented to the SAE Finance Committee.)

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ultimate strength of glass making it still more unreliable as a structural member.

It is foreseeable, however, that continued research will produce a transparent material which when laminated with glass will result in a composite capable of functioning as a structural member in automobile bodies. The future transparent interlayer should have adequate mechanical strength so that its extension at the edges will serve for mounting purposes, thereby carrying the load placed on the glass composite without undergoing distortion or plastic flow.

**Auto-Imagineering** — The automobile, a major factor in superhighways and communication systems as they are now envisioned, seems destined for an increasingly important role. Better driver-vehicle-highway relations, new types of driver control elements, and simplified implementation are major changes looked for by 1980. Vehicle dynamic properties will be improved by new steering and suspension systems to increase convenience, safety, and comfort.

Imagineering in specific terms about design some 20 years from now, opens a complete new field for exploration. Foreseeable "knowables" — giant strides toward aircraft practice; intriguing "probables" such as body skin all way round and under the car — spark imagination to the "why nots," maybe "transparent steel" for automobile roofs as an outcome of physics and chemistry research.

Goya, Gauguin, Vermeer, or Picasso certainly never styled an automobile interior, but their paintings are being used for just that. The "old masters" appear to offer the long-term appeal in color relationships that the fashion trend activity of the Ford Styling Center has been looking for to augment contemporary color and fabric combinations.

**Automatic Transmission Fluids** — Automatic transmission fluids are very complex in nature because they must serve so many functions in the transmission. Briefly, they must serve as (1) the medium for transmitting power in the fluid coupling; (2) the hydraulic medium for a complex hydraulic control system; (3) the medium for transferring and dissipating heat; and (4) the lubricant for a variety of mechanisms.

To do all these things the fluid must, for example, contain:

1. A base oil largely of the high V.I., oxidation stable, Midcontinent variety. Proper dewaxing and the use of pour depressants are desirable to aid low-temperature fluidity.

2. A V.I. improver representative of the intermediate molecular weight range. This provides optimum properties of low-temperature fluidity and shear stability.

3. A seal swelling component to meet rubber swell requirements. A good choice might be a well-refined, oxidation stable naphthenic stock.

Cal Research has developed a bench test that is reported to do quite well in predicting the stability of fluids in transmission. Actually, it is the established oxidation test of the Allison Type C specification, with a change in test temperature. In addition, the test results are looked at more closely. Specifically, it is claimed that this test can be used (1) to predict the stability of a specific oil, (2) to screen the effect of base stock, and (3) to screen the effect of additives.

**Let's Make Better Brakes** — Development of motor vehicle brakes incorporating aluminum has been under way for a decade, with experience indicating that aluminum brake drums fitted with cast iron liners give 100,000 to 200,000 miles of service before liner replacement.

Benefits are said to include appreciably lower operating temperatures, substantially longer lining life, greater brake stability and operating efficiency, and reduced brake noise even after severe usage.

**Getting to the Airport** — Buses, monorail, and helicopters line up as three parts of the "getting to the airport" problem. The solutions needed for good transportation include:

· Expressway planning and construction by city and state at a much faster rate.

· Development and engineering work in order to build a low-priced railroad to the airport.

· Development of 1000-passengers-per-hr helicopter techniques to transport concentrations of jet passengers.

**Truck Refrigeration for Perishables** — Dry ice as a trailer refrigerant has many advantages. In addition to an initial investment savings of about 65%, and no parts maintenance, refrigeration costs are calculable in advance.

"Foam-in-place" insulation — a new type of reefer construction — is based on urethane foams and uses all the properties of urethane. Another promising construction — made by the same foam-in-place techniques — is one in which nodular panels are employed.

**Modern Wear Problems** — Recent tests show that the sliding friction of solids on well lubricated rubber is due primarily to elastic hysteresis loss within the rubber. These observations may be important in the friction skidding and wear of car tires.

Other tests show that the hardest face of a diamond can be polished by a metal if the rubbing speed is sufficiently high. Evidence indicates that this is due to the transformation of diamond to carbon at high surface temperatures.

Preliminary measurements on boron, tungsten, and titanium carbides show that the friction first falls as the temperature is increased and then at about 1000 C the friction rises sharply.

Measurement of the friction of solids at speeds up to 1800 mph show that the sliding resistance of metals decreases as the speed increases and reaches very low values. There is evidence that frictional heating produces high surface temperatures and a softening and melting of the metal at the regions of contact.

A drop of liquid striking a solid surface at impact velocities up to 3500 ft/sec will deform even the hardest surfaces. Such damage can occur on the surfaces of aircraft during high speed flight in rain; in this form it is referred to as rain erosion.

Results obtained on two bench wear tests emphasize the importance of surface condition on wear phenomena. Studies on a Tappet Machine suggest that wear resistance is associated with the formation of surface films.

Fluctuations in the coefficient of friction in a Constant Friction Test probably reflect changes in average shear strength and this variation is primarily an effect of the formation, transformation, and removal of surface films.

**Supporting Turbine Transports** — Greater speed and more precise equipment constitute the challenge in supporting the new turbine transports. Electrical loads alone will require generator power from 12 to 140 kva with good frequency and voltage control.

At the same time new passenger and cargo handling equipment is being designed complete with mockups. Fuel storage and pumping facilities are expanding to meet such demands as 1200 gpm at 35 psi to refuel the Boeing 707.

**Power Steering — Present and Future** — Saginaw's new rotary valve gear power steering system has instantaneous hydraulic response. It is lighter and smaller than the previous gear and has fewer seals and components.

"Natural feel" in parking effort is achieved in the Lincoln through use of a torsion actuated valve.

Variable ratio employing hyperbolic form curves is the most immediately available means for accomplishing "directness" in power steering.

**Accident Investigation** — Accident investigation is a powerful tool for evaluation of aircraft design progress, CAB investigators find. The wreckage-distribution chart — resulting from on-the-spot investigations — and mockups of the engine and of structural sections, serve as important visual evidences in determining "what happened," why, and how.

**Preventive Maintenance** — Preventive maintenance sometimes leads to "over-maintenance." Where time and mileage are determining criteria, it's easy to es-

**AT THE PRODUCTION LUNCHEON:** Anderson Ashburn (left), 1959 SAE Vice-President for SAE Production Activity, discusses a humorous production experience with Del S. Harder of Ford Motor Co. who was guest speaker at the Luncheon. Ashburn was toastmaster.

Harder, in his speech, "The Production Executive's Job in the Coming Years," described cost cutting as the major challenge facing the industrial production manager in the future.

"He will have the job of pushing harder and harder to cut costs and boost productivity. And he will have to innovate and improve, concoct and contrive, and plot and plan as never before if we are to regain our vanishing technological advantage."

**CEP FUND RAISERS** kicked off the 1959 year with a fact-loaded luncheon built around the work of the SAE Technical Board. Three technical committee chairmen and Board Chairman Kelley pointed out future plans and past accomplishments while Finance Committee Chairman Colwell outlined the dollar goals for 1959 and M. J. Kittler, vice-president of Holley Carburetor Co., gave tips on contacting industry's management. Shown at the speakers table of the Cooperative Engineering Program luncheon are (l. to r.) R. P. Trowbridge (Parts and Fittings), Ralph Isbrandt (1959 Board chairman), O. K. Kelley (1958 Board chairman), Joseph Gurski (Materials), C. E. Mines (Aircraft), A. T. Colwell.

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tablish schedules . . . where they are not, a more practical formula must be applied.

Most widely used in nondestructive fleet maintenance testing are penetrant methods and magnetic particle inspection. . . . The newest testing possibility, an electronic instrument — ED-500 — will detect cracks in magnetic or non magnetic materials.

Wheel alignment and balance are important maintenance functions. Alignment maintenance requires correctly designed instruments or gages to measure wheel toe, angles of camber, caster, steering axis, and turning radius, as well as "tracking" of front and rear wheels. "Off-the-car" and "on-the-car" methods are the most widely used in wheel balancing.

Uniform adjustment of all brakes is a "must." Unless equal brake lining to drum clearance is provided for brakes, all design and service efforts are nullified. Brake application may be increased 50% by running equipment with slackened brakes.

**L. Ray Buckendale Lecture:**

**The Design of Planetary Gear Trains** — Planetary gears are used exclusively in all American passenger-car automatic transmissions and almost exclusively in the heavy-duty automatic transmissions. There are a number of reasons for its popularity.

The planetary gear train is more compact than the countershaft gear train designed for the same function. In addition, it eliminates the length required for the radial load-carrying bearings at both input and output gearsets of the countershaft design.

Planetary gears are more efficient in gear action. A fixed countershaft dictates the existence of two sets of gears transmitting the full power and suffering the sliding action loss of the involute gear teeth twice. In the planetary arrangement the gears handle only the differential power; first, there is the input gear loss proportional to the input speed minus the output speed times the input torque; and second, the reaction gear loss in proportion to the output speed times the reaction torque. The two losses are approximately equal. The output member is the "countershaft" carrier, which reduces the operating gear action speed as compared to a fixed countershaft design. The resultant gain is substantial in planetaries designed for small reduction ratios where the input speed minus the output speed is small and the reaction torque is also small.

The planetary train is also more efficient because of smaller bearing losses.

Planetary gearing, in addition, is easier to make quiet than countershaft gearing and is suitable for designs of uninterrupted power shifting.

**Frontiers of Measurements** — Man is outgrowing, and dissatisfied with, present units of measurement. They're inadequately precise. New techniques of measuring are being developed not merely to evaluate physical properties but for broader understanding of materials and creation of better designs and products.

By 1960, the international meter may be defined in terms of krypton 86. Linear devices calibrated to one ten-millionth of an inch, then can enable production line tolerances of one hundred-thousandth of an inch. One of the major opportunities arising from the exploration of outer space can be the placing of measurement platforms beyond the screen of the earth's atmosphere to permit viewing the universe without highly restrictive blinders.

One of the current frontiers of measurement, however, is the determination of new extremes of temperature. At present measurements can be made with confidence to around 6000 F, but million-degree temperatures are contemplated. At the other end of the scale lies the vast field of cryogenic research and prospects of low-temperature production processes, all below four degrees absolute, with progress handicapped by lack of reliable reference points and inadequate precisions.

Military agencies and space ex-

ploration are seeking initial thrust forces in the vicinity of 1,000,000 lb, yet force-measuring devices with dead weight standards, accommodating slightly more than 100,000 lb are adequate for merely one-tenth of requirements.

**Bringing Outdoor Testing Indoors** — Indoor climatic testing provides a 24-hr day means for continuing developmental work on engine cooling, car heating, and air conditioning throughout the year.

In controlled-weather rooms in laboratories, effects of fuel and engine design are often found that otherwise would be hidden by weather variables.

Advances in car cooling are projected as a result of recent laboratory hot room testing of automotive equipment. Development of the *U* factor, expressing car body heat transfer characteristics, and the effect of air infiltration during recirculating air operation are two important outcomes of the tests.

"Hurricane Road" is Ford's answer to the difficulties encountered in testing under natural weather conditions.

**Lightweight Highway Tractors** — General Motors has developed a new tractor, the DLR-8000, for hauling a single trailer at a GCW of 61,000 lb. The vehicle, developed to meet this single objective, has turned out to be very flexible in meeting various highway hauling conditions and in conforming with the conflicting legal requirements of the various sates. (At a GCW of not over 61,000 lb and with a 35 ft semi-trailer, it is said that no other design more closely approaches the legal maximum in all states.)

Another version of this tractor, the DRF-8000, has a bumper-to-front wheel centerline dimension of 28 in. instead of 50 in. Because this model will generally pull heavier loads, it is provided with optional rear axles and axle ratios, optional increased engine power, and other features suited to its heavier payloads.

**Firebird III** — The GT-305 Whirlfire — Firebird III's new regenerative gas turbine engine — embodies new levels of attainment in horsepower per pound of fuel and per pound of engine weight. Coupled with more compactness and greater rigidity, it represents a new milestone in development of vehicular gas turbines.

Chassis design is centered around its "Unicontrol" system. Fully powered servo controls, automatic guidance and speed controls give new handling performance. Front suspension design eliminates mechanical steering connections — and the high-capacity and antiskid brakes with oil-cooled grader retarder supply safe and effective braking under all road conditions.

**Higher Engine Speed and Power** — The present countershaft transmission if properly designed with due consideration to required type of lubrication, balance of rotating parts, adequate bearing mountings, and reduction of external vibrations and misalignments will provide a satisfactory unit for delivering to the driving wheels the available speeds and power of the new higher speed engines.

If the industry decides to increase engine speeds to approximately 4000 rpm, it has a number of choices as to how this may be accomplished without increasing vehicle speeds.

**Test Road Construction** — The world's greatest highway research project, a multi-million dollar fully instrumented operation designed for future road design, building, and maintenance is well under way.

The $22,000,000 test facility, now operating near Ottumwa, Illinois will provide engineers and highway administrators with exact knowledge of the physical requirements of highways and bridges built for present and prospective motor vehicle traffic. The basic objective is to establish significant relationships between performance and traffic for pavements of certain designs under controlled truck traffic with certain loadings.

The studies, made with the aid of delicate road-testing instruments and complex electronic computers, will deal with such subjects as paved shoulders, base types, pavement fatigue, tire size and pressure, and heavy military vehicles. Contemplated also is development of a future condition index useful in predicting the condition of a highway at a future date when subjected to known loading and environment. The data will be used by the Bureau of Public Roads in studies of highway cost allocations and of desirable dimensions and weights of vehicles to be operated on federal and interstate highway systems.

The research project comprises some eight miles of various types of pavement, the 836 test sections ranging from 2½ to 12½ in. in thickness.

Test traffic will operate over the

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**JOHN T. CAHOON** (left), manager, Marketing Research Department, Firestone Tire & Rubber Co., told the SAE Membership Committee how marketing techniques might be applied to building up SAE membership. At right is J. H. Dunn, who is continuing as 1959 chairman of the Membership Committee.

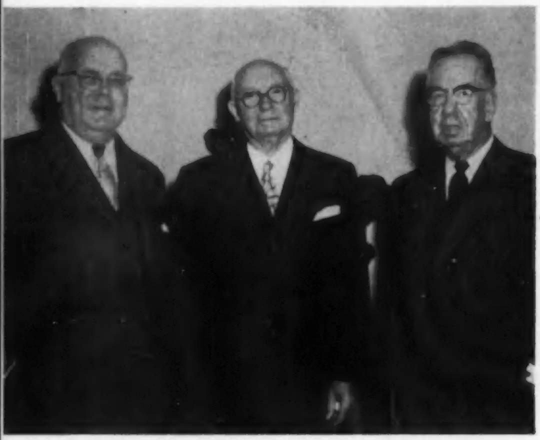
# *At the Reception before the Dinner . . .*

**. . . Automotive industry executives and SAE Past-Presidents made up the roster of guests of honor at the 1959 SAE Annual Meeting Dinner.**

D. R. Lamont, director of research, Socony Mobil Oil Co., and Past-President W. Paul Eddy

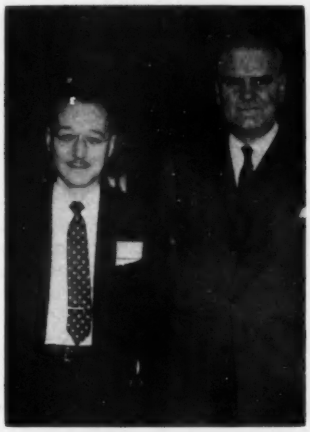
Past-President William Littlewood, Past-President D. P. Barnard IV, Past-President W. S. James, and Past-President Dale Roeder

Past-President Robert Cass, L. L. Colbert, president, Chrysler Corp., Past-President Arthur Nutt, and G. R. McGregor, president, Trans-Canada Air Lines



Past-President J. C. Zeder, Past-President J. G. Vincent, and Past-President A. W. Herrington

SAE Councilor Philip H. Pretz, Past-President J. H. Hunt, SAE Councilor Harry E. Chesebrough, Past-President G. A. Delaney, and Past-President R. J. S. Pigott



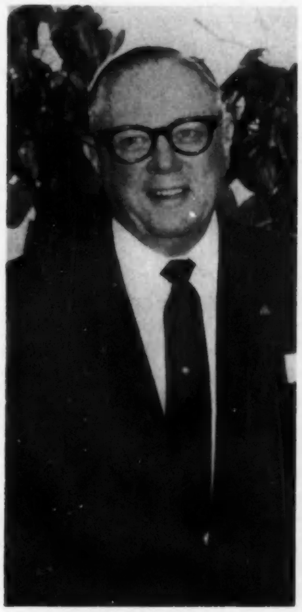
M. J. Kittler, vice-president, Holley Carburetor Co., and Fred W. Parker, Jr., vice-president, Rockwell Spring & Axle Co.

Abram D. Reynolds, vice-president, Reynolds Aluminum Sales Co., Reynolds Metals Co., and Past-President Ralph Teetor

George Romney, president, American Motors Corp.

# *At the Dinner . . .*

**AT THE ANNUAL DINNER,** W. K. Creson (1958 SAE President) (left) was toastmaster; Detroit Section Chairman W. E. Burnett (center), welcomed the diners at the start of the speaking program; and 1959 SAE President Leonard Raymond, in his inaugural address, emphasized the need for long range planning of Society affairs and finances.



**SAE Past-President A. T. Colwell** (left) introduced the paper prepared for presentation at the dinner by T. Keith Glennan, administrator of the National Aeronautics and Space Administration. R. W. Young, president of Reaction Motors, (below) read Glennan's paper when weather conditions prevented Glennan from reaching Detroit in time to speak.

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instrumented roads during two nine-hour shifts daily for two years. Sixty vehicles will operate simultaneously, with 10 additional vehicles held on standby, promising an accumulated 16,000,000 miles of travel.

Drivers, supplied by the U. S. Army Transportation Corps, will be observed for the study of fatigue and the effect of monotonous driving conditions.

The effects of the controlled traffic are recorded by a complex system of electronic and mechanical instruments and digital computers, some of them recording and measuring surface deflections of pavements under any vehicles.

**High Torque Brakes** — Goodrich's new multiple shoe "Hi-Torque" brake makes effective use of all lining contact and eliminates pressure peaks or variations by making the length of each block approximately equal to its width. This design assures that all lining will have virtually unrestricted opportunity to contact the drum surface without deforming.

There are no rigid connections between the lining and the actuation to impair or prevent the radial movement necessary to completely seat the lining surface to the drum surface. Each lining is confined from axial movement by side frames and from rotational movement by torque bars.

Extending through the side frames and the lining is a leaf spring applying a force to the linings toward the center of the brake, assuring positive retraction upon release of the brake.

The brake actuation is, in effect, a flexible hydraulic platform providing complete freedom for lining contact.

The torque developed by each lining is opposed by torque bars welded into the side frames. These torque bars and lining elements are evenly distributed about the 360 degrees of brake circumference. The actuation is by a full-circle, hydraulic expander tube made of fabric reinforced neoprene. This tube imparts direct and equal pressure to all linings. As the linings are not continuous at the torque bar locations, a steel shoe is riveted to the lining base.

In addition to supporting the expander tube, the shoe provides the base for the force of the reretracting springs. Thin steel shields bridge the separation between the steel shoes to keep the tube from extruding after extended service. The expander tube is supported on the inside by the cast torque plate.

When pressure is introduced into the expander tube, the linings move out radially to contact the drum with equal pressure because all activation is from one hydraulic chamber. At no point in the brake drum does the lining pressure ever exceed the brake pressure as contrasted with the uneven pressure pattern over the length of a fixed anchor rigid shoe. By controlling the amount of fluid leaving the brake, retraction of the lining is controlled. By this means, brake adjustment or lining clearance is maintained. As uniform pressure is exerted around the entire brake and self-energization is eliminated, uniform torque will be developed around the entire brake and dispersed evenly through the frames and torque plate. This force is pure torque and does not bend the axle or axle housing.

**Tremendous Trifles in Manufacturing** — Realizing that material cost consumed 51% of its sales dollar, Pontiac launched a program to reduce, substitute, eliminate or conserve both tools and materials. In 1956, the first year of operation, savings totalled $8,524,000. In 1957 they rose to $9,236,000. Last year they fell to $4,807,000, presumably because of smaller volume and the natural loss of potential as the program progresses.

The material utilization program is run by a committee having department heads or assistants for members. And with its subcommittees it permeates the entire organization. Saving is everyone's business and money-saving ideas come from every source.

Alerting the supervisory staff of the car assembly plant to watch for possible economics in the buildup of 1959 pilot run cars brought about a saving of $97,000 through deletion of parts from inner hood panel to outer panel, while analysis of the chassis wiring harness resulted in a saving of $47,000. These are typical of the savings being achieved.

Cost reduction committees can pay off even for small plants. One way they can reduce operating overheads is to analyze production cost per square foot of floor space.

General Electric has a program for value analysis designed to carve "functionless fat" from products.

If any cost in a product does not contribute to making the product work or making the product sell, they get rid of it. If the cost item does contribute to work or sell, then they study it to uncover the best answer while keeping in balance the items of cost, function, and essential quality.

**Splines and Serrations: Advantages of the New SAE Standard** — Simple and effective usage is the keynote of SAE's new simple splines and serrations standard. The designer has been considered first. Spline, serration, and inspection data have been put into a form that pinpoints application rather than tooling problems. (The new standard appears in the 1959 SAE Handbook.)

Major changes include reducing the number of spline fits and types to five. Serrations are of one type and fit. The three types of splines are: flat-root side fit, flat-root major-diameter fit, and fillet-root side fit (each of which has two classes of fit at the sides of the teeth, a "loose fit" and a "close fit"). Tabular information is separated for each type, so the designer doesn't have to "research" complicated tables.

**Control of Exhaust Gas Emissions** — Smog studies of automotive exhaust emissions are now at the stage where the commercial feasibility and practicality of four separate approaches to exhaust gas cleanup can be explored.

Three of the possible approaches to the problem involve the development of muffler devices using (1) high-temperature chemical catalysts, (2) low-temperature catalytic materials, or (3) flame-type afterburners. (Such devices can be made integral with the vehicle exhaust system.)

The fourth approach is the possibility that a carefully administered engine tune-up program in the Los Angeles area may be of great help.

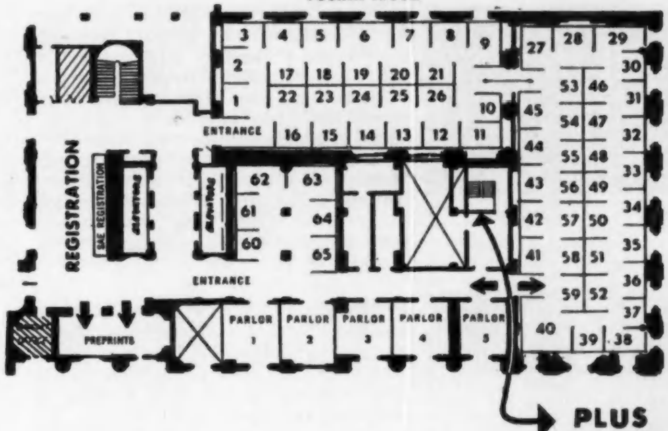
A prototype muffler device is now ready for complete road testing and proving ground evalua-

# 1959 SAE Engineering Display

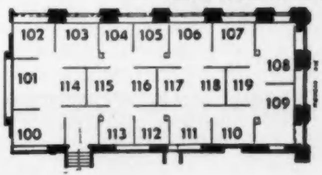
## . . . at the Sheraton-Cadillac Hotel, January 12-16.

### Exhibitors

| | BOOTH NO. |
|---|---|
| Aeroquip Corp. | 18-19 |
| Aluminum Co. of America | Parlor 3 |
| American Bosch Arma Corp., American Bosch Division | 1 |
| American-Radiator & Standard Sanitary Corp., Detroit Controls Division | 45 |
| Anchor Coupling Co., Inc. | 15 |
| Armco Steel Corp. | 7 |
| Associated Spring Corp. | 109 |
| Bacharach Industrial Instrument Co. | 9 |
| Battelle Memorial Institute | 102 |
| Bendix Aviation Corp. | 37-40 |
| Borg-Warner Corp., Warner Automotive Division | 21 |
| Borg-Warner Corp., Warner Gear Division | 20 |
| Bostrom Corp. | 112 |
| Chelsea Products, Inc. | 105 |
| Cities Service Petroleum, Inc. | 2 |
| Cleveland Graphite Bronze Co. | Parlor 2 |
| Committee of Stainless Steel Producers, American Iron and Steel Institute | 108 |
| Continental Motors Corp. | 3-4 |
| Dana Corp. | 60 |
| Deluxe Products Corp. | 61 |
| Detroit Aluminum and Brass Corp. | 13 |
| The Dow Chemical Co. | 57 |
| Dualoc Drive, Inc. | 5 |
| E. I. Du Pont De Nemours & Co., Inc., Elastomers Division, Organic Chemicals Department | 46-47 |
| E. I. Du Pont De Nemours & Co., Inc., Plastics Division, Polychemicals Department | 48-49 |
| The Electric Auto-Lite Co. | 27 |
| Electro-Mec Associates | 115 |
| Enjay Co., Inc. | 43-44 |
| Fabricon Products | 42 |
| Fairchild Engine & Airplane Corp., Al-Fin Division | 14 |
| Fawick Corp., Fawick Brake Division | 106-107 |
| Flexonics Corp. | 58 |
| Fram Corp. | 6 |
| The Garrett Corp. | 59 |
| General Motors Corp., Detroit Diesel Engine Division | 62-63 |
| General Radiator, Inc. | 31 |
| Gillett & Eaton, Inc. | 103 |
| Grob, Inc. | 56 |
| Heli-Coil Corp. | 36 |
| Hercules Motors Corp. | 64-65 |
| Heyer Industries, Inc. | 50 |
| Higbie Mfg. Co., Avon Tube Division | 32 |
| Hoof Products Co. | 16 |
| Hoover Ball & Bearing Co. | 113 |
| Johnson Bronze Co. | 54-55 |
| Kaiser Aluminum & Chemical Sales, Inc. | Parlor 5 |
| Kelsey-Hayes Co. | 10-11 |
| Kistler Instrument Corp. | 33 |
| Lake Shore, Inc. | 116 |
| Lipe-Rollway Corp. | 12 |
| Lisle Corp. | 53 |
| Lord Mfg. Co. | 8 |
| Midland-Ross Corp., Owosso Division | 114 |
| Monroe Auto Equipment Co. | 22 |
| Olin Mathieson Chemical Corp., Metals Division | 104 |
| Perfect Circle Corp. | 110-111 |
| Perfex Corp. | 24 |
| Reynolds Metals Co. | 34-35 |
| Rosan, Inc. | 28 |
| Ross Gear & Tool Co., Inc. | Parlor 4 |
| The Satullo Co. | A-B |
| Spray Products Corp. | 119 |
| Stratoflex, Inc. | 51-52 |
| Sun Oil Co. | 101 |
| Thompson Ramo Wooldridge, Inc. | 100 |
| The Torrington Mfg. Co. | 23 |
| Tyrex, Inc. | 117 |
| Vance & Villani | 118 |
| Vickers, Inc. | 29-30 |
| Waukesha Motor Co. | 41 |
| Jervis B. Webb Co. | 17 |
| Wyman-Gordon Co. | 25-26 |
| Zollner Corp. | Parlor 1 |




**PLUS**
*one flight down . . .*
**MEZZANINE FLOOR**



tion by all motor vehicle companies. This device, which is a low-temperature catalytic converter, has been fabricated in sufficient quantity during the couple of months for simultaneous studies and tests by all motor vehicle companies. It can be made by conventional steel construction, and it is estimated it will cost $150 per installation.

Many of the problems associated with exhaust gas controls and possible smog relief are far from being completely understood by either Los Angeles or industry experts. Extensive research and engineering development work lies ahead before any "package solution" can be made available.

Meanwhile, the industry's assistance in sponsoring long-term research on air pollution health problems is being studied.

# About SAE Members


Hosterman


Shumate

**FRED O. HOSTERMAN** has been made president and general manager of Weston Hydraulics, Ltd. Formerly, he was executive vice-president and director of sales for the company. Hosterman was 1956 SAE vice-president representing Aircraft Activity.

**A. E. SHUMATE** has been made executive vice-president and assistant general manager of Weston Hydraulics, Ltd. Formerly, he was vice-president and assistant general manager for the company.


Kuhn


Aylward

**TERRY W. KUHN** has been made president of Bohn Aluminum & Brass Corp. Formerly executive vice-president, he has been with Bohn since 1928. He has served as a director of the company since 1950.

**RICHARD C. AYLWARD** has been made vice-president of sales of Bohn Aluminum & Brass Corp. He was formerly general sales manager of the same company.


Squibb


Aukers

**GEORGE R. SQUIBB** has been made president of Automotive Conversion Corp., Michigan. Prior to this, he was chief project engineer for Process Development Section, General Motors Corp., Detroit.

**ALBERT J. AUKERS** has been made vice-president in charge of industrial sales of Victor Mfg. & Gasket Co. He was formerly manager, industrial sales, for the same company.


Droge


Hertel

**HENRY N. DROGE** has been made general sales manager of Kollsman Instrument Corp. He was formerly assistant general sales manager for the company.

**WILLIAM A. HERTEL** has been made manager of Government Sales and Engineering with Weatherhead Co. He was formerly engineering manager for Weatherhead.

**THOMAS A. ROBERTSON** is now manager, tire engineering, with Firestone Tire & Rubber Co. He was formerly manager for truck and tractor tire engineering of the same company.

**MELVIN P. HERSHEY** is now manager of engineering for passenger, racing, and airplane tires and related products with Firestone Tire & Rubber Co. Formerly, he was manager for passenger, racing, and aircraft tire engineering of the same company.

**M. GEORGE BRUSH** is now manager of automotive tire engineering, Detroit, Firestone Tire & Rubber Co. Brush joined Firestone in 1947, and in 1953 became a sales engineer stationed in Detroit.

**ERIC G. BOEHM** has become assistant general manager of Buffalo Bolt Co., a division of Buffalo Eclipse Corp. He was formerly general manager of Buffalo Hydraulics Division, Houdaille Industries, Inc.

**J. R. SPLITSTONE** has become assistant general manager, Automotive Division with Timken Roller Bearing Co. He was formerly Detroit district manager for the Automotive Division of the same company.

**JAMES J. ROBSON** has been named director of tire engineering and development of Firestone Tire & Rubber Co. He succeeds the late **WALTER E. LYON.** Robson has been manager of tire engineering and development for Firestone since 1953.

**LESTER L. BELTZ**, chief engineer, Ford Motor Co., has been made chairman of Vehicle Lighting Committee of the Automobile Manufacturers Association. He is succeeding **HARRY C. DOANE,** assistant to vice-president, charge of engineering for General Motors Corp.


Robertson


Hershey


Brush


Boehm


Splitstone


Robson

**JAMES B. EDWARDS** has been made assistant to the vice-president of engineering, transport and aircraft systems, with Douglas Aircraft Co., Inc. Edwards previously was assistant to the chief engineer, Santa Monica Division, as well as chief of the Division's aircraft operations engineering section of Douglas.

**SAE'S 1950 PRESIDENT, JAMES C. ZEDER,** vice-president of Chrysler Corp., has been named chairman of a fund raising campaign for The University of Michigan's Memorial-Phoenix Project of research on the peaceful uses of atomic energy.

**ELIJAH P. CUNNINGHAM** is now manager of technical sales service on petroleum chemicals with Organic Chemicals Division, Monsanto Chemical Co. Formerly, he was in charge of the company's research engine laboratory at St. Louis.

**HENRY A. JEWELL** has been named director of procurement and material with Saco-Lowell Shops. Formerly, he was director of purchases for Long Mfg. Division, Borg-Warner Corp.

**JOSEPH T. OSTERMAN** has become Chicago district representative with Electric Auto-Lite Co. Formerly, he was assistant manager, Chicago district office for American Bosch Division, American Bosch Arma Corp.

**NORMAN D. COSNER** is now manager with Dearborn proving ground department, Ford Motor Co. Formerly, he was section supervisor for Ford's Dearborn Test Area Department.

**CHARLES W. MODERSOHN** is now staff engineer at Beloit Iron Works. Prior to this, he was manager of engineering for the Automotive Division, Warner Electric Brake & Clutch Co.

**ARTHUR L. HAUBERT** is now general manager at Allied Service & Supply Co. Formerly, he was sales engineer for Colorado Kenworth Corp.

**ROBERT H. YEAKEY** has become truck field service representative with Ford Division of Ford Motor Co. Formerly, he was associate engineer for Boeing Aircraft Co.

**WARREN H. CARHART** has become area sales manager, Precision Products Division of Western Gear Corp. Formerly, he was sales manager for Texas Alloy Products Co.

**CLINTON G. ROOD, JR.,** is now sales engineer with Refiners Petroleum Co. He was formerly sales engineer for Wholesale Marketing Division, Pure Oil Co.

**HENRY FORD II** told the Associated Press last month that tariff restrictions as a means of preventing infiltration of foreign products, including automobiles, "never would win over the rest of the world that we are relying on to appreciate us. We have got to learn to compete without such restrictive action."

**J. LUKE HOFFMAN,** vice-president of sales, retired as directive head of Columbus Bolt & Forging Co. Detroit office. He will continue with the company in an advisory capacity and as director. **THAYER M. COWMAN** succeeds Hoffman. Cowman was formerly a sales engineer with the company. **LOUIS J. AURE** has been made chief engineer of product development with Columbus Bolt & Forging Co. He was formerly chief field and new product engineer for the same company.

**THADDEUS MARTIN ALEXANDER** is now mechanical engineer, GS-11 with U. S. Naval Ordnance Test Station at Pasadena, Calif. Formerly, he was assistant mechanical engineer for the Department of Street Railways, City of Detroit.

**JAMES C. WILSON** has been made president of Cal Wilson Equipment, Ltd. Prior to this, he was vice-president of sales for Canadian Steel Improvement, Ltd.

**THOMAS E. ZIMMERMAN** is now a technical staff member with Hughes Research & Development Laboratories, Hughes Aircraft Co. Zimmerman was Chrysler missiles test & development engineer for Chrysler Missiles, Chrysler Corp.

**ANDREW BADARAK** is now resident engineer at the San Jose Assembly Plant of Ford Motor Co. Prior to this, he was a production product engineer for Ford.

**LOUIS VINCZE, JR.,** is now assistant to the president of Robinson Blower & Engineering Corp. Prior to this, he was systems installations engineer for Convair Division, General Dynamics Corp.

**CLAYTON M. SHEPSTONE** is now Rockford sales representative with Industrial Products Division, Warner Electric Brake & Clutch Co. Formerly, he was sales engineer for Mechanics Universal Joint Division, Borg-Warner Corp.

**EDWARD R. DYE** has been made president of New Products—a newly organized research, development, and engineering company. He was formerly with the Head Safety Design Research Department of Cornell Aeronautical Laboratory, Inc.

## Littlewood heads IAS

**SAE PAST-PRESIDENT WILLIAM LITTLEWOOD,** vice-president — equipment research of American Airlines, Inc., has been elected 1959 president of the Institute of Aeronautical Sciences. He took office at the Annual Meeting Honors Night Dinner of the IAS at the Hotel Astor in January.

Elected as IAS vice-presidents are the following SAE members: **CLARENCE L. JOHNSON,** vice-president — research and development, Lockheed Aircraft Corp.; **RAYMOND C. SEBOLD,** vice-president — engineering, Convair Division, General Dynamics Corp. **JEROME LEDERER,** director, Flight Safety Foundation, was elected Treasurer.

**WILLIAM C. ROBERTSON** has been named manager, Federal-Mogul Division of Federal-Mogul-Bower Bearings, Inc. Formerly, he was plant manager for the same company.

**KERMIT M. HART** succeeds Robertson as plant manager. Hart had been plant superintendent for the same company.

**HUGH S. CHRISTIAN** is now chief engineer, Electronics Division of Diamond Power Specialty Corp. Formerly, he was chief mechanical engineer for Motorola Inc.

**JOHN DANIEL MILLER** has become development engineer "A" of Aerojet-General Corp. He was formerly analytic engineer for Power Generators, Inc.

**G. LAWTON JOHNSON** has become an associate with Boyden Associates, Inc. Prior to this, he was president of Greer Marine Corp.

**STANLEY W. WOLFE** is now design engineer with Convair Division, General Dynamics Corp. Prior to this, he

Continued on next page

# About SAE Members

. . . continued

was a graduate engineer trainee for Ford Motor Co.

**LAWRENCE H. HODGES** has been made assistant works manager at J. I. Case Co. Prior to this, he was chief product engineer with the same company.

**ROBERT R. ROTH** has been made assistant chief product engineer with J. I. Case Co. Formerly, he was project engineer for tillage implements, Minneapolis-Moline Co.

Hodges

Roth

Esper

Hopeman

Cook

Marshall

LeFevre

Chew

**A. H. ESPER** has been made executive engineer in charge of all proving ground operations of Ford Motor Co. Formerly, he was manager for Dearborn Test Area Department for the company.

**VICTOR HOPEMAN** has been made executive engineer of the testing laboratories of Ford Motor Co. Formerly, he was manager of Kingman, Ariz., proving ground for Ford.

**B. D. KELLER** has been named manager of Kingman, Ariz., operations at Ford Motor Co. He had been Hopeman's assistant.

**NORMAN D. COSNER** succeeds Esper as manager of the Dearborn proving ground at Ford Motor Co. He was formerly section supervisor, Dearborn Test Area Department for Ford.

**WILLIAM A. McCONNELL** has been named head of the vehicle laboratories department at Ford Motor Co. He was formerly technical assistant, Engineering Division for Ford.

**WILLIAM L. COOK** has been made executive engineer with Diamond T Motor Truck Co. Formerly, he was assistant chief engineer for the same company.

**THOMAS J. MARSHALL** has been made sales manager, Federal-Mogul Division of Federal-Mogul-Bower Bearings, Inc. Marshall was formerly assistant sales manager.

**WILLIAM F. LeFEVRE, JR.**, has been made head of the newly organized engineering research and development section of Freightliner Corp. Formerly, he was chief engineer for the same company.

**NORMAN B. CHEW** has been made chief engineer of production of the newly organized section of Freightliner. Formerly, he was assistant to the chief engineer for the same company.

**WILLIAM E. RICE** has become new products engineer with Transmission & Axle Division, Rockwell-Standard Corp. He was formerly automotive engineer for Clark Equipment Co.

**RICHARD C. St. JOHN** has become chief, Test Division of the U. S. Army Transportation Research & Engineering Command. Prior to this, he was unit advisor in San Francisco for the U. S. Army.

Rice

St. John

**GEORGE M. BUNKER** has become a director of Bulova Watch Co., Inc. Bunker is president and chairman of the board of The Martin Co.

**WILLIAM SCHOELLKOPF, JR.**, is now a sales representative with Union Oil Co. of Calif. Formerly, he was a salesman for Union Oil Co.

**JAMES J. CREAMER** is now zone sales manager in Cleveland for New Departure Division of General Motors Corp. Formerly, he was zone sales manager for their Indianapolis office.

**DONALD G. SPRIGINGS** is now a mechanical engineer with Delta-Star Electric Division, H. K. Porter Co. Formerly, he was project engineer for Electro-Motive Division, General Motors Corp.

**ORVAL E. LORENZ** is now district manager in Pennsylvania with Chain Belt Co. Formerly, he was district manager for their Minneapolis office.

**JAMES J. STUDENIC** is now southwest regional manager at Cummins Engine Co., Inc. Prior to this, he was a representative for Cummins' Eastern region.

**WILLIAM R. SPENCE** is now design engineer with Douglas Aircraft Co., Inc. He was formerly hydraulic engineer for Gar Wood Industries, Inc.

**CHARLES R. ALLEN** has joined the staff of D. K. MacLennan Co. of Los Angeles as technical representative for Misco Precision Casting Co., Michigan. Formerly, he was senior project engineer for AiResearch Mfg. Co.

**ROBERT G. HASKELL** is now an experimental engineer with Pratt & Whitney Aircraft, Division of United Aircraft Corp. Prior to this, he was a sales engineer for General Motors Corp.

**JOHN F. GORDON**, president, General Motors Corp. has been elected to the board of directors of the Automobile Manufacturers Association.

**NICOLAS I. FLORESCU** is now production manager at Caprin, Ltd. Previously, he was development engineer for Parmatic Engineering, Ltd.

**H. C. HARBERS** has been named president and general manager of the newly formed Western Unit Corp. He was formerly vice-president in charge of manufacturing for Cook Brothers Equipment Co.

**ARNOLD RISTOW** is now sales manager with Western Unit Corp. Formerly, he was sales manager for 5th Wheel Division, A. O. Smith Corp.

**Obituaries . . . see page 127**

*37 papers . . . 13 sessions . . . 8 production panels . . . all scheduled at the Sheraton-Cadillac Hotel, March 16-20, constitute the technical program for . . .*

# SAE National Automobile Week

TWO long standing SAE events, the National Passenger Car, Body, and Materials Meeting and the National Production Meeting are joining together in 1959 to present an integrated program dealing with the design, engineering, and production of automobiles, trucks, and buses.

Forest R. McFarland (Buick Motor Division, GMC) general chairman for the Passenger Car, Body, and Materials Meeting, reports that the four participating Activity Committees have developed technical sessions for Monday, March 16, through Wednesday, March 18.

Note these highlights . . .

Forest R. McFarland

General Chairman

Passenger Car, Body, and Materials Meeting

Harold G. Warner

General Chairman

Production Meeting

**Indoor Endurance Testing** — Annual model changes require that testing programs be fitted into shorter periods since it is no longer permissible to have delays due to weather. Engineers have learned to program "outdoor" tests indoors. Specific testing procedures for automatic transmissions, sound and vibration testing, and cold room techniques will be described.

**Design Features of European Trucks** — Relatively unfamiliar to U.S. transportation experts are many interesting features incorporated in European trucks. Highlighted will be several of the innovations in wide use abroad.

**Present-Day Approach to Fatigue** — Latest practical and theoretical developments in the study of fatigue failures of highly stressed parts of the modern automobile will be reviewed. Detailed analysis of fatigue testing of suspension members and non-ferrous applications will be undertaken.

**American and Foreign Light Car Analysis** — Why are foreign cars like they are? Why are American cars like they are? Where can unitized bodies be employed to best advantage? Under what conditions are rear engines used? European engineers will review these features and explain why they are used in preference to the familiar American design. A review of American light cars will outline the engineering considerations utilized in determining basic design features.

**Electronic Techniques for Testing Passenger Car Bodies** — Body engineers, planning for annual model changes, are utilizing new electronic techniques to expedite testing. The procedures employed and results obtained for measuring riding comfort, testing body mechanisms, and structural testing will be covered.

**Multi-Purpose Bodies** — Paralleling the growing application of station wagons in the passenger car field to haul both people and cargo, new multi-purpose bodies have been introduced in the commercial field. Speakers who have followed this development in Europe, Asia, and America will summarize this new trend and project some of the developments the industry can look for in the years ahead.

**New Automotive Finishes** — Several of the new finishes for car bodies introduced this year represent the most significant advances in metal finishing in a number of years. Presented will be the first technical details, including description and application of the new lacquers, enamels, and primers.

**Components Affecting Ride and Handling** — Three recently announced significant engineering developments affecting ride and handling are freon gas-filled shock absorbers, new tire materials and construction, and low profile tires. This session will include a detailed engineering discussion of the freon type shock absorbers and bring out the true engineering facts on the controversial tire area.

**Passenger Car Exhaust Systems** — Silencers are important in motor vehicles — both from the standpoint of minimizing noise as air is breathed into the engine and meeting local requirements for exhaust systems. Results of experiments into the fundamentals of exhause silencers will be summarized. Importance of muffler location and how mufflers can be designed so as to minimize corrosion will be covered.

The Production Meeting, being held the latter part of **AUTOMOBILE WEEK**, will include two technical sessions and four production panels on both Thursday, March 19, and Friday, March 20. Harold G. Warner (Cadillac Motor Car Division of GMC), general chairman, and his committee working with participating groups have developed an extensive program for production engineers and executives. Plans for The Production Forum have been developed by Forum Chairman W. B. Shimer (Chrysler Corp.) and his committee. L. I. Woolson (Chrysler Corp.) is Forum sponsor.

**Shall We Build a New Plant or Remodel — Panel** — When facilities must be expanded or replaced, all possibilities must be reviewed, including new and remodeled plants, the economics, human considerations, and locations.

**How to Save Valuable Floor Space — Panel** — Obtaining optimum production per square foot of floor space is a key factor in lowering manufacturing costs. What steps can be taken to accomplish this?

**Scheduling: Relationship of Capital Expenditures and Inventory — Panel** — Having the right part — in the right place — at the right time — in the right number — this is, primarily a scheduling job. How can this obligation be met successfully?

**How to Save Time and Money on Press Tooling — Panel** — Many ingenious ways to save time and money on tooling have been found. Still, the search goes on as tooling costs continue to rise. The panel will consider

# 1959 SAE

# National Meetings

- **March 16-20**

  SAE National Automobile Week: including National Passenger Car, Body, and Materials Meeting and National Production Meeting, Sheraton-Cadillac, Detroit, Mich.

- **March 31-April 3**

  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.

- **June 14-19**

  Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

- **August 10-13**

  International West Coast Meeting, Hotel Georgia, Vancouver, B. C., Canada

- **September 14-17**

  National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 5-10**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 26-28**

  National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- **October 27-28**

  National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- **October 28-30**

  National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill

## SAE National Automobile Week

. . . continued from preceding page

cast-to-shape dies, plastic and Kirksite dies, die automation, production dies, and electronic discharge machining of dies.

**Electronic Data Processors — A Practical Tool for Management Control** — Papers at this technical session will discuss how, where, and why the automobile industry is using computers. Subjects include control of parts distribution and specific uses of electronic data processing equipment in design and production control.

**Sprayed Metal Coatings** — Methods, properties, and applications of sprayed metal coating, in the field of wear, corrosion, and salvaging will be covered in papers at this technical session.

**Cold Forming — Today and Tomorrow — Panel** — A review of the increasing number of applications for cold forming involving long runs of steel parts. Cold extruded and cold headed parts are replacing units made previously by multiple operations on automatic screw machines or other methods. Discussion will cover savings resulting from reduction in the amount of steel required, improved mechanical properties, increased production rates, and elimination of certain machining operations.

**How Can We Reduce Metal Finishing Costs — Panel** — Providing surfaces that are satisfactory for painting or plating and repairing metal surface defects represent a substantial cost. The panel will consider faster finishing methods, improved tooling, how to reduce damage and finishing cost due to handling, belt finishing, tumbling techniques, prefinished stock, and abrasive performance.

**Economy of Correcting Assembly Troubles at the Source — Panel** — An effective way to fight rising production costs is to find and eliminate defective parts before they find their way into sub-assemblies or final assemblies. Methods of achieving this objective will be discussed.

**Can We Have Standards for Preventive Maintenance — Panel** — Where preventive maintenance standards can be used to insure against plant breakdown, to insure better conditioning of equipment, and as a contribution to lower costs, will be the subjects investigated.

**Have You Forgotten Something?** — Three technical papers at this session will cover many details often overlooked when planning for new equipment and processing.

**Is Your Product Ready for the Customer?** — Examples of things being done to maintain and improve quality of the product will be covered. Specific practices used in assuring customer satisfaction will be included.

# X-14, a New VTOL Research Tool

Based on a paper by

JAMES A. O'MALLEY, JR.
and
LEE C. LANDPHAIR
Bell Aircraft Corp.

**Fig. 1 — USAF X-14 in hovering position.**

A TACTICAL aircraft — the USAF X-14 — is a new research tool designed to study characteristics of VTOL aircraft. One of its major purposes is to develop engine modifications permitting horizontal engine installation. The plane is shown in Fig. 1.

The USAF X-14 incorporates existing aircraft components wherever possible: the wing of a Beech Bonanza lightplane, the tail surfaces of a Beech T34A Mentor trainer. The Armstrong-Siddeley "Viper" engines are located in the forward fuselage in a fixed horizontal position. Thrust diversion is accomplished through a diverter mechanism that rotates the engines' exhaust gases. The two jet exhausts are located close to the aircraft centerline, giving the effect of a single jet impinging on the ground. The wings are large and low, with greatly reduced loading. The span of the aircraft is 34 ft, with a net length of 27 ft and an overall height of 9 ft.

Developed by Bell Aircraft Corp. for the Navy and Air Force, the new plane is an effort to increase the scope of the findings obtained with the previous Air Test Vehicle built in 1953. The X-14 has already contributed to studies of ground effects and pilot control of VTOL aircraft. The former have been found to depend upon size of wing surface, proximity of wing and fuselage to the ground, wing aspect ratio, spacing between exhaust areas, and fuselage contouring. Reaction control of the X-14 is achieved manually through a constant bleed system, which produces less than 50 deg/sec$^2$ angular acceleration in roll and about half that in pitch and yaw.

**To Order Paper No. 95B . . .** on which this article is based, see p. 6.

# Additive Protects Against 3 Types of Wear

THE additive zinc dialkyl dithiophosphate gives protection against wear by:

- Faster mating of contact surfaces through temperature-controlled chemical polishing.
- Formation of tightly ahered chemical films having antiwelding properties.
- (Possibly) production of more wear-resistant surfaces through selective chemical etching of the metal surfaces.

This protection is given against adhesive, abrasive or cutting, and corrosive wear. Tests indicate that, as the operating conditions become more severe, the chemical activity of this additive is increased. Also, that more protection is provided under conditions of high load and temperature whether they exist during the initial stages of running or in subsequent operation.

The anti-wear properties of these dithiophosphates appear to some researchers to be peculiar to each formation of alkyl groups, making generalization on the effectiveness of primary versus secondary alcohols impossible.

There is also some evidence, others say, that deposit-forming tendencies of a lubricant are affected by the type of zinc dithiophosphate used.

Other additives prevent oil oxidation and bearing corrosion but do not contribute antiwear or extreme-pressure characteristics to any appreciable extent. Some additives which give a high degree of antiwear protection are pro-oxidants while others are corrosive to bearings, but none are multipurpose to the extent of having the balanced performance of zinc dithiophosphate.

Recent radio tracer studies with a 4-methyl-pentyl-2 zinc dithiophosphate made from radioactive zinc, phosphorus, and sulfur, conducted in both laboratory equipment and in an actual engine, have revealed the absorption properties of bearing surfaces.

From consideration of the radiation properties of zinc$^{65}$, $P^{32}$ and $S^{35}$, it appeared that absorbers could be used to distinguish between these three sources of radiation. $Zn^{65}$ is a gamma emitter, $P^{32}$ is a hard beta emitter, and $S^{35}$ is a soft beta emitter. Suitable calibrations were made so that it was possible to determine quantitatively the relative amounts of radio zinc, radio phosphorus, and radio sulfur absorbed.

A comparison between the laboratory and engine results were in general agreement. However, the absorption on the engine bearings was slightly greater than on the bearings used in the non-engine experiments where the bearings were merely soaked in the oil at the same temperature. Since the temperature at the bearing surface is probably higher than the bulk oil temperature, it is thought that decomposition and film formation are accelerated under local heating conditions at the bearing surface.

In the laboratory, the amount of sulfur which was rapidly absorbed corresponds to one monolayer of dialkyl dithiophosphate.

The amount of zinc which was absorbed (in the first 5 min) corresponded to one monolayer of closely packed zinc atoms.

In the engine, the bearings were found to have a film of radioactive material which was not removed by washing in toluene or wiping.

There was an excess of zinc absorption over phosphorus and sulfur and an excess of phosphorus over sulfur. This was true of both engine and laboratory tests. The zinc absorption appeared to take place at least in part by replacement of other metal atoms at the bearing surface.

The phosphorus absorption appears to involve at least in part absorption of some compound which is not dithiophosphate but a reaction product derived from it. This is further evidence that partial decomposition is involved in the successful performance of zinc dithiophosphate.

Other recent tests, however, have shown that a zinc dialkyl dithiophosphate additive can result in an increase in small-scale roughness of valve-lifter-foot surfaces over that obtained by operation of the same parts with zinc-free oil. It was also shown that the small-scale roughness could be reduced by subsequent operation of the

parts on oils containing no zinc dialkyl dithiophosphate.

Further tests indicated that this increase in small-scale roughness occurs with both steel and HCI lifters, but that there is a wide difference in the nature of the resulting steel and HCI surfaces. Indicated also is that:

- The antiscuff performance of lubricants containing zinc dithiophosphates is dependent on both the rate of surface-additive reactions and the competing rates of wear.
- The thermal stability of the additive is a factor in determining the performance of the zinc dithiophosphates as antiscuff agents.
- Increased concentrations tend to reduce the tendency to scuff.
- Once scuffing occurs, increased additive concentrations, or increased temperature, may result in an increase in the wear rate of steel lifters. However, no effect of additive concentration seems to appear at high load.

It seems clear that wide difference in the roughness of valve-lifter-foot surfaces can result from the operation of these parts on lubricants containing different additives.

Material for the foregoing article was drawn from: "Performance of Zinc Dithiophosphates as Lubricating Oil Additives" by C. S. Scanley and Read Larson, American Cyanimid Co. (Paper 107C); "A Look at the Effects of Lubricant Additives on Surfaces" by P. A. Bennett, Research Staff, GMC (Paper 107B); and "Some Concepts of the Action of an Antiwear Additive" by S. B. Twiss, E. H. Loeser, and R. C. Wiquist, Chrysler Corp. (Paper 107D).

**To Order Papers Nos. 107B, C, or D** on which this article is based, see p. 6.

# Compressor Can Be Common Denominator

Based on paper by

**C. W. MODERSOHN**

Warner Electric Brake & Clutch Co.
(Presented before SAE Texas Section)

INVESTIGATION of the dynamic drive characteristics of compressors for automotive air conditioning systems — undertaken in connection with designing a clutch — illustrated how the compressor may act as a needed dynamic common denominator in drive design.

Fig. 1, showing the combination of compressor and clutch characteristics resulting from this study, indicates this "common denominator" relationship.

It shows, for example, that the clutch can pick up and accelerate a loaded compressor whenever the compressor peak-running-torque curve falls below the slip-torque curve of the clutch.

Further, since the static or zero-slip capability of the clutch is greater than the highest peak torque required by any of the chosen peak loads, the clutch will not slip in driving such loads if they are imposed after the clutch is locked in.

For example, this clutch is not capable of invariably picking up the stationary compressor with 400-psi head pressure, 60-psi suction pressure, and accelerating it to 700 rpm. It is, however, capable of picking up the compressor at some lower combination of pressures, such as 350–50, and driving without slip, even through the pressure may pump up to 400–60 and somewhat above. If the higher pressure pickup characteristic is required, it is thus apparent that design modifications must be made in the clutch. On the other hand, a change in the characteristics of the system by, for example, increase in condenser effectiveness would reduce pressures to meet the capability of the clutch.

It is important to note that certain types of compressors may have a pickup torque requirement which is in excess of the peaks experienced in running. In such cases, the *pickup* peak of the compressor must be used as a comparative factor, rather than the running peaks.

**To Order Paper No. S111 . . .** on which this article is based, see p. 6.

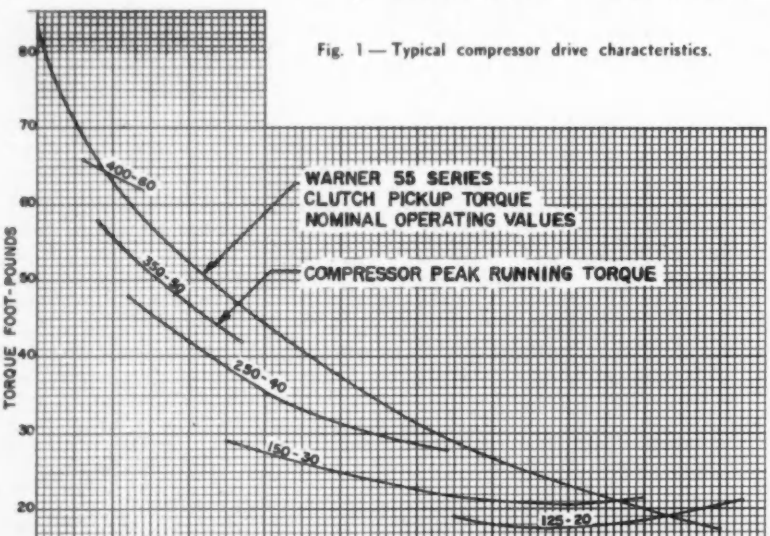



Fig. 1 — Typical compressor drive characteristics.

# VTOL Aircraft Need Stabilizing

Based on paper by

**J. W. BAXTER and R. C. FINVOLD**

Ryan Aeronautical Co.

VTOL aircraft need to be stabilized because of: (1) the thrust control problems inherent in the system and (2) the slowness of the pilot's reactions in correcting deviations in altitude and position.

The desirability of a stabilization system is shown by a pilot's response judgment in making corrections of attitude. The pilot has the ability to detect angular errors in the range of 2–3 deg or more. With his response rate, the pilot must limit his correction of such an error to 2–3 deg per sec$^2$ or he will overcorrect — and the VTOL aircraft will be unstable. The difficulty in doing this is that a 2–3 deg per sec$^2$ correction rate is a very small percentage of the total control ability the pilot can call upon. In fact, it is only 1–2% of the available angular acceleration that the aircraft controls can produce. Thus, the pilot must limit his use of the control stick to 1–2% of its travel If he makes use of velocity information, he can control attitude through acceleration. However, this requires his constant attention, which he is not always able to give to the problem.

The thrust control problems inherent in the VTOL system develop because the aircraft are essentially acceleration vehicles, with all other controls de-

pending upon acceleration control; because highly responsive thrust control is necessary to maintain control of altitude; and because the engine must be capable of delivering thrust equal to the weight of the plane.

Thrust control is a greater problem in afterburning than in nonafterburning engines. The former do not seem to have satisfactory control characteristics for VTOL aircraft, because of the large gap between maximum thrust without afterburning and minimum afterburning thrust. Response is required in tenths of a second for VTOL; however, work at Ryan indicates the response of afterburning engines to be close to a second. Also, the requirement that the VTOL engine be able to operate at thrust values equal to the gross weight of the airplane, regardless of load, is not satisfied by some types of afterburning engine controls.

In spite of these disadvantages, however, tactical versions of VTOL probably will take advantage of the high thrust-to-weight ratio of the afterburning turbojet engines. With adequate overall thrust control, the afterburning engines can satisfy VTOL requirements as the nonafterburning engines now do.

**To Order Paper No. 95A . . .**
on which this article is based, see p. 6.

# Changes Enable Brake To Meet Heavy-Duty Needs

Based on paper by

**F. T. COX, JR.**

Rockwell-Standard Corp.

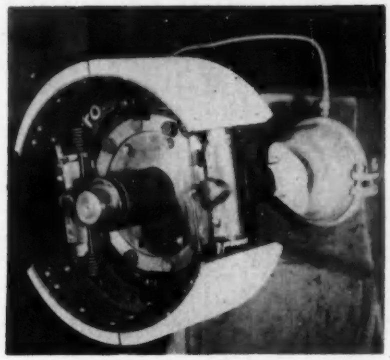
INCREASED loads, greater speeds, and higher horsepowers have placed greater demands on brakes for heavy-duty commercial vehicles. Add to this a trend to smaller tire rim diameters (to lower the center of gravity of the vehicle for stability, and also to allow more load space between allowable maximum height and truck floor levels) and you get some idea of the problems facing the brake manufacturer.

Inasmuch as most trucks are now designed to accommodate an internal-expanding-shoe drum brake, we decided to try to obtain the ultimate from this type brake. To get the required performance, we decided that it would be necessary to depart from the fixed-anchor type of brake, despite its simplicity and long record of excellent performance.

A brake of balanced design was needed; one where each shoe did a proportionate share of the work. Further, it was decided that, if at all possible, the brake diameter should be reduced. (At present, with a 16½ in. brake and a 20 in. base tire, and with drum of sufficient weight, there is little air space between the outside diameter of the drum and the inside diameter of the tire rim. This not only lowers the effectiveness and shortens the life of the brake, but in many cases, shortens the life of the tires by bringing their temperatures to a point that causes rapid deterioration.)

After investigating the brake location and mounting means available on today's trucks, it was determined that a brake of 15 in. diameter was about the smallest that could be used and still meet all requirements. This meant additional air space between the drum and the rim, and therefore better cooling.

Right angle actuation, accompanied by a wedge device fitted with antifriction rollers for spreading the shoes, permitted assembly closer to



General arrangement of heavy-duty brake with right angle actuation.

the actual brake mounting and reduced the space required for mounting.

The abutment load had to be removed from the actuation means. Therefore, the brake was designed with an integral spider which takes the abutment load and, in addition, houses and gives support to the actuating device.

The brake can be actuated either by air or hydraulic means. The hydraulic actuation is somewhat different than those presently used on service brakes as the hydraulic cylinders have been moved outside the brake, thereby removing them from the heat brought about by braking, and eliminating the susceptibility of the brake fluid to boil.

By changing the design of the drum brake and without materially affecting the remainder of the vehicle, we have shown an increase in brake performance, an increase in resistance to fade, and an increase in wear life. In addition, it has been possible to reduce the weight of the brake and to fit it into spaces smaller than formerly used. It has also been found possible to operate this brake with far less volume of air than required for former designs.

**To Order Paper No. 96B . . .**
on which this article is based, see p. 6.

# *Many Smog Control Devices Being Studied*

Based on talk by

**WALLACE LINVILLE**

Los Angeles Air Pollution Control District

(As reported by Paul L. Garver, SAE Southern California Section Field Editor)

AUTOMOTIVE smog control is being investigated along many lines. Studies indicate that:

- Control of nitrogen oxides may be feasible through spark timing, water injection, or richer air-fuel ratios. Changes in basic combustion-chamber design that apply some of the principles recently learned by Dr. A. J. Haagen-Smit may also help.
- Induction system devices, such as the throttle cracker, dashpot, deceleration fuel shutoff, and carburetor isolating valve do not seem as promising today as they did a year ago, as the overall reduction of hydrocarbons possible with this type of device is only about 24%.
- Exhaust system devices, such as the decelerator afterburner, the Clayton Clear-Air muffler, and the catalytic muffler, are showing considerable promise. Some of them are in the prototype testing stage.
- The fuel approach, according to the Los Angeles Air Pollution Control District, offers a potential reduction in eye irritation, plant damage, and increase in visibility. Work of the API and the Air Pollution Foundation showed, however, no significant difference in the ozone-producing ability of various types of fuels, or between present fuel used in the Los Angeles basin and a 0%-olefin fuel.
- Fuel evaporation loss from carburetors alone is about 30 tons per hr at an ambient temperature of 100 F, in Los Angeles County. Methods of reducing this loss are being explored.

# Close-Tolerance Holes Present Build-Up Problem

Based on report by secretary

N. L. SMITH

General Dynamics Corp.

ONE factor causing the drilling of oversized holes in soft materials, particularly in the aluminum alloys, is what is commonly termed "build-up." It is the result of frictional heat and pressure combined to cause the metal particles to weld to the cutting tool and inside diameter of the bushing.

Although various coolants and lubricants help to prevent build-up, in assembly-type work the use of lubricants and coolants are usually not permissible or practical.

The heat and pressure created by the cutting tool and the drill bushing actually cause particles of the aluminum alloy to fuse with particles of the steel tooling. The difference in the thermal coefficient of expansion of the aluminum and steel can cause the steel drill bushing to flake-off near the weld line and continued build-up and resulting flaking-off results in oversized holes.

No positive cure for this problem is known. However, several things can be done to minimize it. The flutes of the drill may be polished. The drill jig may be designed to allow maximum clearance between the part and the bushing to allow chip escapement clearance. Cleaning and reconditioning standards can be established. An employee education program to train employees to recognize when a drilling tool should be changed is also helpful.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: **A. E. Hill**, General Dynamics Corp.; **O. A. Foss**, North American Aviation, Inc.; **L. C. Todd**, Douglas Aircraft Co., Inc.; **J. N. Willits**, Ryan Aeronautical Co.; **M. Mendels**, Rohr Aircraft Corp.; **J. R. Hendel**, Northrop Aircraft, Inc.; and **W. E. Burnham**, Boeing Airplane Co.

(This article is based on a secretary's report of a production panel entitled "Hole Preparation in Close Tolerance Work." This report — along with 10 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-325. See order blank on p. 6.)

# Prediction Technique Used to Land Aircraft

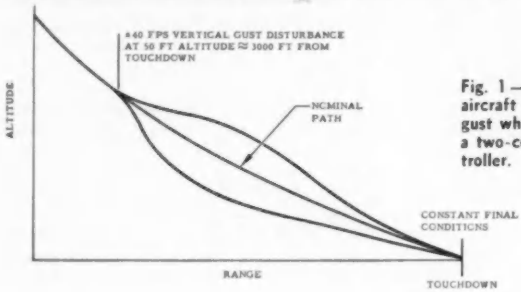



**Fig. 1 — Trajectories of an F-100F aircraft when meeting a vertical gust while landing under control of a two-condition terminal flare controller.**

Based on paper by

E. R. BUXTON

Autonetics Division,
North American Aviation, Inc.

EXTENSIVE flight testing has demonstrated the possibility of using linear fixed-gain flare controllers to land aircraft consistently.

Assuming knowledge of the exact future time that touchdown should occur, the servo problem is to bring the altitude to zero at this time and at a prescribed negative of change of altitude. And to do this with a minimum of control action.

Servo design technique for this problem is remarkably simple, particularly if the dynamic process can be described by linear differential equations. The determination of a variable at a specified future time depends only on knowledge of the current state or initial conditions, the control action over the prediction interval, and the transient response of the variable to each initial condition or control action over the interval. The continuous prediction of altitude and altitude rate at the desired touchdown time thus is easily formulated. With the method formulated, it is appropriate to form an error by comparing the predicted result with that desired and use normal feedback means to slave the process continuously to the desired end condition. Systems of this type have been named "terminal controller."

A two-condition terminal flare controller is used for aircraft landing because both altitude and altitude rate have prescribed end values. There is an altitude predictor and an altitude rate predictor. The rate, or inner loop, predicts the minimum constant control input that will bring the sink rate to the desired value at touchdown time. The outer loop prediction is based on the output of the inner control loop and the initial conditions which define altitude at the terminal time assuming no control action. This error is introduced as a proportional control signal through the gain constant *K*, which is the only gain that the servo designer is free to choose. This coefficient is remarkably insensitive in systems designed to date and is usually set to reduce the outer loop error to zero during the first 10% of the control interval.

Various approach angles are accommodated with no changes in the controller. Sink rate and range dispersion are essentially invariant at approach angles from 3 to 15 deg. Fig. 1 shows trajectories resulting from simulated vertical gust disturbances up to 40 fps. The final conditions are achieved with precision following a completely nonoscillatory response, therefore, an appropriate new path is always established with minimum control action.

**To Order Paper No. 88C . . .**
**on which this article is based, see p. 6.**

# Kibre Pendulum—New Test Control Concept

Based on panel report by

J. D. DYER

Lockheed Aircraft Corp.

A GOOD production test cost-control concept is illustrated by the "Kibre Pendulum" (Fig. 1.) The pendulum swings about it's pivot, subject to the forces of "motivation." The forces are "airworthiness" (an exaggerated sense of absolute assurance, testing, and retesting at every opportunity) and "economy" (an exaggerated sense of eliminating production tests — be-

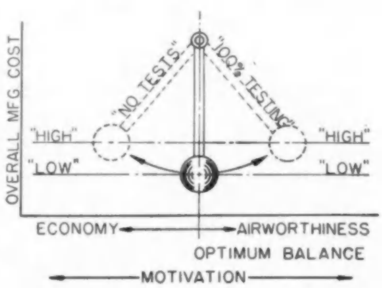



**Fig. 1 — "Kibre Pendulum" cost control concept for testing.**

cause testing is expensive). If one considers the extremes "100% nondestructive qualification testing of each and every part in production" or "no testing," the pendulum in each instance is driven to an area of high costs. The more assurance designed into a test, the higher the cost for equipment, manpower, facilities, and paperwork. The high cost of no tests is not as obvious until one considers the cost of one aborted flight or costs attributable to secondary damage resulting from a primary failure.

Optimum testing may be determined by first dividing tests into two categories. These categories are 1. "engineering specified tests" dictated by flight safety and contractual requirements, 2. "manufacturing tests" which are tests required if quality control techniques in manufacturing do not guarantee quality assurance. The categories should be independently considered in relation to the following production stages and cost factors:

**1. Stages for Production Functional Testing**

| | |
|---|---|
| Source | $ |
| Receiving | $$ |
| Subassembly | $$$ |
| Assembly | $$$$$ |
| Preflight | $$$$$$$$$$ |
| Flight | $$$$$$$$$$$$$$$$$$$$$$$$ |

Use progressive testing at logical "responsibility" points to keep problems at a minimum. (The dollar signs are not intended to be a quantitative presentation, but to give an idea as to the cost of a rejection at various stages.)

**2. Cost Factors for Consideration**

| Increase Cost | Decrease Cost |
|---|---|
| Minimum source test | Optimum source test |
| "Deferred" tests | Earliest possible testing |
| High rejection rate | Low rejection rate |
| Large number of parts in process | Small number of parts in process |
| Complex tests and equipment | Simple tests and equipment |
| Precision measurement | Go — No Go concept |
| Over or under ratio personnel | Optimum skill level |
| Many production tests | Few production tests |
| Flight tests | Ground tests |
| Narrow band of acceptability | Wide acceptable range |
| Inadequate lead time | Adequate lead time for tests and equipment |
| Nonstandard tests and equipment | Standard tests and equipment |
| "Ideal" parts and systems | Adequate parts and systems |
| Laboratory equipment | Commercial equipment |

An optimum test plan will result if the logic of the "Pendulum" concept is applied.

# Computer Calculates Pressure-Time Diagram

Based on report to SAE Electronic Computer Advisory Committee by

**J. D. WOLFE,** General Motors Corp.

TO compute engine bearing loads when designing an engine, it is necessary to know the *P-T* curves at various engine speeds. The program to be described was written to fulfill this need. Previously, about two days were required to hand-calculate four curves; by using this program, any number of curves could be computed at one time with a wait of less than one day for the results.

The program was written in SAP (SHARE Assembly Program) language for an IBM 704 computer. Approximately three weeks were required to write and debug the program.

### Input Data

The program will accommodate three variations in input data; that is, the brake and friction torques, the indicated torque, or the imep may be specified. One of these options plus the manifold depression and the mbt spark advance must be specified at each engine speed for which a *P-T* curve is desired. In addition, the following items are required:

1. Engine displacement.
2. Exhaust back presssure.
3. Exhaust valve opening.
4. Compression ratio of this engine.
5. Compression ratio of engine of imep data.
6. Stroke.
7. Connecting-rod length.

### Output Format

Two columns of data are printed out with this heading:

*P-T* Curve for ??? RPM
Theta deg Pressure-psig

The left column contains the crankshaft angles and the right column contains the corresponding chamber pressures in psig. The range of crankshaft angle is from 180 deg btdc to 180 deg atdc; the increments of crankshaft angle are 3 deg from the mbt spark point to the assumed maximum point (Fig. 1) and 6 deg elsewhere. This results in approximately 70 points for each curve.

### Method of Calculation

If either of the torque input options is used, the imep will be computed from it; the imep may be for an engine similar to the one in question except for compression ratio. It is corrected as follows:

$$\text{imep}_{\text{this engine}} = \text{imep}_{\text{known engine}} \times \frac{\text{compression ratio}_{\text{this engine}}}{\text{compression ratio}_{\text{known engine}}}.$$

The theoretical compression and expansion curves are then computed.

The problem at this point is to modify the theoretical curves so as to produce a continuous curve that will closely agree with actual data. Certain assumptions are made in this modification which are the result of empirical information. On the compression side, the actual curve is assumed to depart from the theoretical curve at the mbt spark point. Also, the actual maximum chamber pressure is assumed to be 80% of the theoretical maximum expansion pressure and to occur at 15 deg atdc. The expansion curve is also assumed to drop linearly from the exhaust valve opening point to the exhaust back pressure at 180 deg atdc (Fig. 1).

Using these assumptions, plus the restriction that the slope of the resultant curve must not exceed 50 psi per deg, a smooth curve is fitted from the mbt spark point through the maximum point and into the expansion curve.

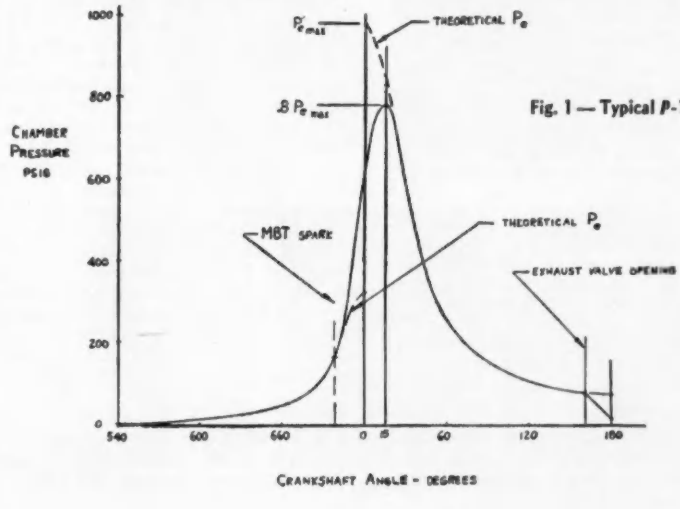



Fig. 1 — Typical *P-T* diagram.

# Isbrandt Appointed Chairman of 1959

# Seven New Members Start

**RALPH H. ISBRANDT**, American Motor's director of automotive engineering and research, has been appointed chairman of the 1959 Technical Board by SAE President Leonard Raymond.

Isbrandt assumes his new SAE post after serving as a Board member for two years. His appointment is linked with the addition of seven new Technical Board members.

A current member of the Passenger Car Activity Committee, Isbrandt began his career as a chassis designer at the A. O. Smith Corp. In 1929, he joined Nash Motors and, in 1936, he went to Firestone Tire & Rubber Co. There, he was assigned to special development work in aircraft and motor vehicle suspension systems. Later, Isbrandt became vice president and general manager of the Firestone Aircraft Co.

In 1947, two years after joining Kaiser-Frazer Corp. as chief chassis engineer, Isbrandt was made chief aircraft engineer.

Rejoining Nash in 1953, Isbrandt served as chief design engineer and executive engineer of Nash and, when Nash and Hudson consolidated, of American Motors.

Isbrandt studied engineering at the Universities of Wisconsin and Toledo.

**M. G. BEARD**, American Airlines' assistant vice president of equipment research, has been chairman of SAE Committee S-7, Cockpit Standardization, since it was formed in 1951. Two years after S-7 began to function as a standards group, the entire committee received the Flight Safety Foundation Award for Safety.

Beard's current Society activities include being secretary of the Metropolitan Section. In 1950, he was general chairman for the New York Aeronautic Meeting. Since then, he has acted as dinner chairman for that meeting on several occasions.

Beard, who studied engineering at the University of Michigan, was chief engineer and director of flight engineering at American Airlines before assuming his present position.

**ROBERT R. BURKHALTER** has been with the Dana Corp. for the past 28 years. He was appointed to his present post as executive engineer in 1954.

In addition to serving as 1958 SAE Vice President for Truck and Bus, Burkhalter has been a member of the Overseas Information Committee, Buckingdale Lecture Committee, Parts and Fittings Committee, Transportation and Maintenance Activity Committee, and the Detroit Section Board.

Before assuming his current position, Burkhalter was engaged in the development of truck, bus, and passenger car transmissions and clutches for the Spicer Mfg. Co.

Burkhalter studied engineering at the University of Toledo.

**G. E. BURKS** is vice president of engineering and research for Caterpillar Tractor Co. He came to the company in 1930 through the Holt Manufacturing Co. Burks' work at Caterpillar began as a designer. After the Engineering Department was consolidated in Peoria, he headed a small engineering and research group. He subsequently became assistant chief engineer, chief engineer, and director of engineering before assuming his present position in 1955.

Burks served as an SAE Councilor in 1949 and 1950. His interest in young people is reflected by his efforts to encourage the membership of young engineers in technical societies. He has been very active in the activities of the Boy Scouts of America.

**GEORGE W. MORK**, chief engineer of Bucyrus-Erie's Commercial Crane and Excavator Division, is chairman of the SAE Presidential Advisory Committee on Construction and Industrial Machinery. In addition to serving as 1955 chairman of the Construction and Industrial Machinery Technical Commitee, Mork has worked on many CIMTC subcommittee projects.

An SAE member for 16 years, Mork was chairman of the National Tractor and Farm Machinery Meeting in 1954.

Prior to joining Bucyrus-Erie in 1930, Mork was associated with the Universal Portland Cement Co. and the Clyde Iron Works. He received a B. S. degree in Mechanical Engineering from the University of Minnesota in 1926.

**JOHN G. MOXEY, JR.** is assistant director of Sun Oil Company's Research and Development Division. His association with Sun Oil Co. began in 1935, shortly after he received a bachelor's degree in Mechanical Engineering from Swarthmore College. Later, he returned to Swarthmore for the degree of Mechanical Engineer.

In 1952, Moxey was SAE Vice President for Fuels and Lubricants. For many years, he has been active in work of the Coordinating Research Council (which is sponsored jointly by SAE and API).

Moxey is well known as the author of numerous technical papers on fuels and lubricants and their adaption to automotive equipment.

**D. R. SHOULTS** assumed his present position as general manager of General Electric's Aircraft Nuclear Propulsion Department in 1953. Except for a 6-year absence, he has been with GE since 1925. From 1945–1950, Shoults was successively vice president of Bell Aircraft, vice president of the Martin Co., and director of engineering for ARO, Inc.

The 1952 SAE Vice President for Aircraft, Shoults has also served on the Aircraft Powerplant Activity Committee. More recently, he has been the SAE representative on the Daniel Guggenheim Medal Board and a member of the Nuclear Energy Advisory Committee.

Shoults received a B. S. degree in Electrical Engineering in 1925 from the University of Idaho.

**RAYMOND W. YOUNG** is general manager of Reaction Motors, a division of the Thiokol Chemical Corp. He assumed his present position in April 1958 when Reaction Motors merged with Thiokol. Previously, Young was president and a member of the Board of Directors of Reaction Motors.

A recipient of the Manley Memorial Gold Medal, Young received the Presidential Certificate of Merit for participation in the development and production of military aircraft powerplants in time of war.

A former vice president of engineering at Wright Aeronautical Corp., Young studied engineering at Yale. He

# Technical Board

# 3-Year Term

is presently a member of the Aircraft Powerplant Activity Committee. He served as SAE Vice President for Aircraft Engines in 1945 and has been a member of the Coordinating and Research Committee and the Manly Medal Award Committee.

Remaining on the Technical Board are the following members whose terms expire at the end of 1959.

*A. P. Fontaine* — Bendix Aviation Corp.
*R. H. Isbrandt* — American Motors Corp.
*M. J. Kittler* — Holley Carburetor
*W. M. May* — Mack Trucks, Inc.
*R. W. Rummel* — Trans World Airlines, Inc.
*E. C. Smith* — Republic Steel Corp.
*E. C. Wells* — Boeing Airplane Co.
*A. E. Williams* — Fruehauf Trailer

Members whose Technical Board terms end in 1960 are:

*Peter Altman* — Continental Motors
*E. C. Brown* — Austin-Western Co.
*M. L. Frey* — Allis-Chalmers
*G. J. Huebner, Jr.* — Chrysler Corp.
*Oliver K. Kelley* — Buick Motor Division, GMC.
*A. A. Kucher* — Ford Motor Co.
*J. W. Larson* — Chance Vought Aircraft, Inc.
*Arthur Nutt* — Lycoming Division, Avco Mfg. Corp.
*E. B. Ogden* — Consolidated Freightways, Inc.

1959 Board Chairman Isbrandt has selected the following Board members to serve on the Executive Committee: G. J. Huebner, Jr.; O. K. Kelley; A. A. Kucher; Arthur Nutt; and D. R. Shoults.

The seven men whose Technical Board terms just ended are:

*C. F. Arnold* — Cadillac Motor Car Division, GMC.
*Trevor Davidson* — Bucyrus-Erie Co.
*W. H. Graves* — University of Michigan.
*W. M. Holaday* — U. S. Department of Defense.
*A. E. W. Johnson* — International Harvester Co.
*C. L. Sadler* — Sundstrand Aviation Division, Sundstrand Machine Tool Co.
*D. D. Streid* — Jet Engine Dept., General Electric Co.

**1958 Technical Board Chairman Oliver K. Kelley (left) chats with In-Coming Chairman Ralph H. Isbrandt at the Technical Board Luncheon held during Annual Meeting in Detroit last month.**

**Beard**

**Burkhalter**

**Burks**

**Mork**

**Moxey**

**Shoults**

**Young**

# SAE Awards

Eighteen of the 3000 participants in SAE technical committee work were honored at a Technical Board Luncheon during Annual Meeting last month. They were awarded SAE Certificates of Appreciation for having furthered the development of technical information and specifications used by the aeronautical and automotive industries.

Above, Past-President William Creson (left) awards a Certificate of Appreciation to Howard Field. Looking on is 1958 Technical Board Chairman O. K. Kelley.

Allen

Bonney

Field

Heinen

Lentz

Mead

Mertz

Mileti

One of the men most instrumental in generating SAE interest in body engineering is **EDWIN L. ALLEN.** An active SAE member since 1925, he served as chairman of the Body Engineering Committee in 1956 and 1957. Allen's work is also reflected in projects of several subcommittees.

As chairman of Committee A-4 on Aircraft Instruments, **F. S. BONNEY** has diligently guided the development of minimum performance instrument standards for use in commercial turbine-engine aircraft. In addition, he has encouraged an awareness of the air transport industry's future instrument needs.

Known to many as the 'dean emeritus' of aircraft hydraulics, **HOWARD FIELD** has been a member of Committee A-6, Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment for 18 years. He has also contributed much toward the achievements of Subcommittee A-6C, Hydraulic Pumps, Motors, Air Compressors.

As chairman of the Fuels and Lubricants Technical Committee, **C. M. HEINEN** is trying to strengthen SAE's position in this area. He is respected by both the petroleum and automotive members for his unbiased handling of committee matters. During the past year, Heinen has been actively seeking answers to the smog problem in Los Angeles.

Simplification of aircraft ignition systems has been a concern of **L. R. LENTZ** who is a member and former chairman of the Aircraft Gas Turbine, Ram-Jet and Rocket Engine Ignition Subcommittee. Lentz is currently vice-chairman of the Ignition Research Committee.

Morrow

Pollard

Rea

Sackett

Schall

# Certificates of Appreciation to 18 Engineers

During the 10-year chairmanship of **H. C. MEAD**, the Lighting Committee's Lamp Subcommittee has progressively raised the standards for all types of motor vehicle lighting devices in the interest of safety. During this time, the Subcommittee developed specifications for the new 4-unit system which is used extensively on 1958 cars. In addition, it has revised the specifications for the 7-in. sealed beam headlamp units.

The fact that the basic materials used in todays' jet engines conform to SAE material specifications is directly related to the efforts of **J. C. MERTZ**. As chairman of the AMS Corrosion and Heat Resistant Alloys Committee, Mertz expedited the development of badly needed jet engine material specifications during the Korean War.

Under the guidance of **J. A. MILETI**, Subcommittee A-6C on Aircraft and Missile Hydraulic Pumps, Motors, and Air Compressors has become an increasingly important authority in its area of endeavor. Since his appointment as chairman in 1954, Mileti and fellow members have skillfully handled many industry and Service problems.

A past chairman of the Iron and Steel Technical Committee's Panel A on Steel Producers, **JAMES G. MORROW** is a recipient of the ASA Standards Medal and president of the Canadian Standards Association. In many unofficial instances, Morrow has advanced an SAE point-of-view at ASA and ABC meetings. His work on the unified screw thread standards and international drafting practices is well known.

A significant advance in aircraft hydraulic systems was made when **F. H. POLLARD** sponsored the incorporation of Type II (– 65 to 275 F) requirements into MIL-H-8775. Revision of this document (which is of prime importance to the aircraft hydraulic engineer) set off a series of revisions to subsidiary documents. Currently Pollard is vice chairman of Committee A-6 on Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment.

**GEORGE A. REA** was chairman of the Tube, Pipe, Hose, and Lubrication Fittings Technical Committee for four years. He is also a past chairman of the Hydraulic Power Controls Subcommittee of the Construction and Industrial Machinery Technical Committee.

**RAY SACKETT'S** vitality and keen sense of humor often transformed routine tasks into meaningful human experiences. As secretary of SAE technical committee activities in Detroit from 1942 to 1957, Sackett generated unusual enthusiasm and cooperation among technical committee members.

**MYRON SCHALL** made significant contributions to the Transmission Committee as past-chairman of the Design Standards Subcommittee and as a member of the Performance Subcommittee. He has been active in the standardization of terminology and performance methods for hydrodynamic and automatic transmissions. Currently, Schall is chairman of the Transmission Committee.

As chairman of two SAE standardization groups, **H. B. SLUSHER** assumes a unique position. As such he has fostered the development of torque values for fittings and lever ends and the clarification of aeronautical terms in Committee E-21 on General Standards for Aircraft Engines and E-21's Identification Marking Panel, respectively.

An enthusiastic advocate of Construction and Industrial Machinery Technical Committee projects, **P. J. SPERRY** has successfully coordinated uniform test codes to make them mutually acceptable to both the CIMTC and the Tractor Technical Committee. A former CIMTC chairman, Sperry was recently appointed to the SAE Presidential Advisory Committee on Construction and Industrial Machinery.

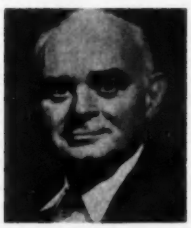
The constructive comments of **WARREN A. TAUSSIG** on technical proposals at Transportation and Maintenance Technical Committee meetings have been invaluable to the group's progress. A former SAE Vice President for Transportation and Maintenance, Taussig has been a TMTC member for over 10 years and an active participant in the work of its subcommittees.

Commended for a unique ability to bring conflicting issues to a practical solution, **H. D. WILSON** instigated extensive revisions in the Electrical Section of the SAE Handbook. A former chairman of the Electrical Equipment Committee, he is currently chairman of the Storage Battery Subcommittee.

**C. M. WRIGHT** has played a significant part in focusing Society attention on solutions to automotive drafting problems. In addition to doing an outstanding job as an SAE representative in ASA, Wright is chairman of the Automotive Drafting Standards Committee. He has been active as a member of the Parts and Fittings Committee, Screw Threads Committee, and the Tube, Pipe, Hose and Lubrication Fittings Committee.


Slusher


Sperry


Taussig


Wilson


Wright

# Rambling . . . THROUGH THE

***Built-in venetian*** blind effects in automotive glass are possible future solutions to the twin problems of heat and light control in this material . . . according to Dr. James E. Archer, Pittsburgh Plate Glass Co.'s director of research. These "slats" would incorporate, reflect, and absorb changes in heat and light radiation.

Present solutions, such as heat absorbing glass, strike an optimum balance between night driving requirements for visible transmittance, and the desired reduction of heat radiation in daytime driving. However, since about half of the sun's heat radiation lies in the visible part of the spectrum, this approach has built-in limitations.

The newer coatings for glass, which reflect a substantial portion of the heat radiation from the sun, Archer reported, are another present solution . . . but, greater overall heat rejection efficiency *should* be possible by reflection, rather than by absorbtion. (**PITTSBURGH SECTION** in November.)

• • •

**During the first nine months of 1958,** 7.3% of the cars sold in this country were foreign cars, compared to less than 1% in 1955. During the same period of time, however, station wagon sales went up 7%, and the percentage of cars equipped with power brakes and power steering increased even more. These trends, including that of the small car, reflect an interest in cars designed to fulfill a specific need. (A. J. Pahnke, of DuPont's Petroleum Laboratory, at **MID-CONTINENT SECTION'S** December meeting.)

• • •

## *PFP presentations at section meetings*

By the time ballots of SAE Constitutional amendments are received by the membership, at least 4,000 members and guests in 41 local groups will have attended scheduled meetings on Planning for Progress. Under the supervision of W. F. Ford, information coordinator of the Planning for Progress Committee, 60% of the Sections, Groups, and Divisions in the U. S. and Canada held PFP talks by Annual Meeting time.

Film slides and script comprise the kit of material, emphasizing the part the proposed Sections Board will play in PFP. The presentation was prepared by Ford, with minor embelishments by local speakers, with slides prepared by Ross Peterson, member of the original Sections Board Information Committee.

Meeting attendance has run equal to the normal number of people turning out for the regular Section events. In larger Sections — such as Chicago, Philadelphia, Cleveland, Milwaukee — this figure is about 20% of the Section membership. Smaller Sections — such as Washington, British Columbia, Atlanta — show a higher percentage, up to 50%. This appears to follow the regular tendency for the smaller Sections to attract a greater proportion of its area membership.

# *sae section meetings*

BUFFALO

**March 2** . . . George W. McLellan, Corning Glass Works, "New Applications of Glass & Glass Ceramics in the Automotive Industry." Wishing Well, 1190 Chili Ave., Rochester. Dinner 7:00 p.m. Meeting 8:00 p.m.

**March 24** . . . Robert F. McLean, GM Styling. "Automotive Styling for the Future — Firebird III." GM Training Center, Clarence, New York. Dinner 7:00 p.m. Meeting 8:00 p.m.

CHICAGO

**March 10** . . . Fuels and Lubricants Meeting. Knickerbocker Hotel, 163 E. Walton St. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Sponsored Social Half-Hour 6:15 to 6:45 p.m.

**March 23** . . . "Army Wheel Vehicles." LaSalle Hotel, South Bend, Ind. Dinner 6:45 p.m. Meeting 8:00 p.m.

DETROIT

**March 11** . . . Student Activity Meeting. Zora Arkus-Duntov, Chevrolet Motor Division, GMC. "European Car Developments." Rackham Educational Memorial, 100 Farnsworth. Dinner 6:30 p.m. Meeting 8:00 p.m.

METROPOLITAN

**March 10** . . . Special Section-Wide Meeting. Three afternoon sessions starting at 2:30 p.m. **Session #1** — Sponsored by Diesel Engine and T & M Activities. Hans Egli, chief engineer, AiResearch Industries; Benjamin Barish, Thompson Products; James A. Hardy, Schwitzer Corp. "Turbo-Charging of Diesels." **Session #2** — Sponsored by Air Transport & Aeronautic Activities. Panel Discussion. "Million Airplanes for the Future." **Session #3** — Sponsored by Fuels & Lubricants and Passenger Car Activities. Henry Jennings, Fleet Management Consultant; J. W. Lane, Socony Mobil Oil Co.; J. O. Sibley, U. S. Fidelity & Guaranty Co., Representative of General Motors Corp.; F. K. Glynn, Automotive Consultant. "Crankcase Oil Drain Periods." Henry Hudson Hotel, 57th St. and Ninth Ave., NYC. Sponsored Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Price $6.50 to members, $7.50 to non-members. Dinner speaker to be announced. SAE President Leonard Raymond will be honored guest.

**March 24** . . . Dr. Miles C. Leverett, manager, Development Laboratories, Aircraft Nuclear Propulsion Dept., General Electric Co. "Aircraft Nuclear Propulsion." Garden City Hotel, Garden City, L.I., N.Y. Meeting 7:45 p.m.

MID-MICHIGAN

**March 2** . . . R. V. Lohmiller, Bell Tele-

# SECTIONS

While visiting the **UNIVERSITY OF BUFFALO,** SAE Past-President W. K. Creson meets with (left to right) Dean of Engineering Paul E. Mohn; Creson; SAE Past-President Ralph R. Teetor; and Chancellor C. C. Furnas. Creson addressed a group of senior engineering students, and Teetor was principal speaker at the **BUFFALO SECTION** meeting that evening.

• • •

**Hard work, team play,** and constructive use of leisure time, were recommended by Harry A. Stuhldreher at **CENTRAL ILLINOIS SECTION'S** Ladies Night in December.

Speakers and Section Officers included, left to right, Section Chairman W. J. Lux; Main Speaker Stuhldreher, vice-president, U. S. Steel Corp; Peoria City Manager Herbert Fritz, coffee speaker; and Technical Chairman John W. Gilbert.

phone Laboratories, Inc. "Nike Hercules Missile." Hotel Winona, Bay City, Mich. Dinner 6:30 p.m. Special Feature: Movie on DC-8.

MILWAUKEE

**March 6** . . . "Engine Mountings for Vibration Control." Paper to be presented jointly by James W. Sherrick, Bruce A. Kindgren, project engineers, Lord Mfg. Co. Milwaukee Athletic Club, 758 N. Broadway. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

**March 16** . . . C. A. Grinyer, vice president engineering, Orenda Engines, Ltd. "Development of The Iroquois Engine." Sheraton-Mount Royal Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m.

NEW ENGLAND

**March 3** . . . Dean Peacock, chief engineer, Marine & Industrial Division, Chrysler Corp. "Application of Marine Engines & Related Equipment." M.I.T. Faculty Club, 50 Memorial Drive, Cambridge, Mass. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Father & Son Night — Movies on Outboard Racing.

PHILADELPHIA

**March 11** . . . Transportation and Maintenance Activity Meeting. E. P. White, head, automotive section, Aluminum Co. of America. "Commercial Automotive Applications for Aluminum." The Engineeers' Club, 1317 Spruce St. Cocktails 6:00 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

PITTSBURGH

**February 24** . . . SAE President Leonard Raymond. "How Tomorrow's Problems Challenge Today's Research." Mellon Institute, Pittsburgh.

SPOKANE-INTERMOUNTAIN

**March 18** . . . C. J. Wilhite, manufacturing sales, Cummins Diesel. "Latest Developments in Diesel Engines." Caravan Inn, Spokane. Dinner 7:00 p.m. Meeting 8:00 p.m.

VIRGINIA

**March 23** . . . Fleet Men. Round Table Discussion. "Tractor & Trailer Maintenance." William Byrd Hotel, Richmond. Dinner 7:00 p.m.

WASHINGTON

**March 17** . . . C. Hohmann, assistant chief engineer, Vickers Inc. "Missile Cryogenics — The Handling of Liquid Gas." Occidental Restaurant, Pennsylvania Ave. at 14th St., N.W. Dinner 7:00 p.m. Meeting 8:00 p.m.

## Briefs of SAE PAPERS

continued from page 6

and results obtained in corrosion deposition tester and high temperature bearing test.

### GROUND VEHICLES

**Trends in Automotive Electrical Equipment, D. C. REDICK, W. C. EDMUNDSON. Paper No. S114** presented Sept. 1958 (Indiana Sec) 66 p. Pt 1: Passenger car equipment; generator-battery system and its basic components; table showing battery output achieved from 1925–58; future requirements, new concepts and improvements. Pt 2: Heavy duty equipment: special needs of bus, truck, farm tractor, and construction (off highway) equipment.

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These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

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### ALSO AVAILABLE

**1958 SAE AIRCRAFT MANUFACTURING FORUM . . . SP-325** consists of reports on 11 panels, as follows:

**Weapon System Reliability, reported by K. R. McCREADY, secretary.** Outlines the organizational and functional aspects of reliability control. Discusses customer-prime contractor and prime contractor-vendor aspects of reliability. Proper design and assembly practices for reliability are also examined.

**Ground Support Equipment for Missiles, reported by RAY NELSON, secretary.** Failure of ground support equipment has been responsible for many of the missile launching failures. Discusses how manufacturers can and must help to serve ground support equipment reliability problems.

**Control of Manufacturing Costs by Line Supervision, reported by AMOS W. ANSHUTZ, secretary.** Discusses how to establish a climate of cost consciousness. Also, participation by line supervision in preplanning, control of line costs, and costs resulting from changes. Examines cost and performance reporting.

**How to Build Quality, reported by R. W. HEARL, secretary.** Tells how to coordinate quality methods with

continued

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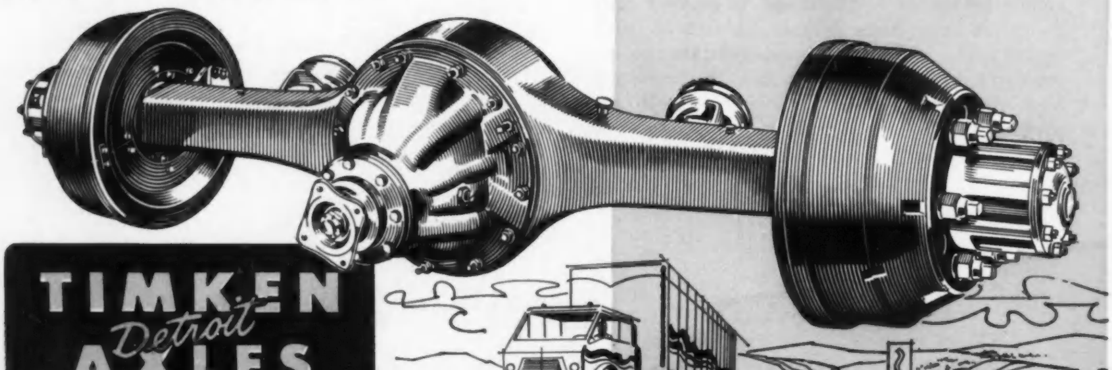

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## Briefs of SAE PAPERS

continued from page 112

production engineering, how to use tool proofing as a means of building quality, and how to train to assure quality.

**Manufacturing Techniques of High-Temperature Materials, reported by GIL C. CADWELL, secretary.** Compares today's fabricating techniques and requirements with what will be needed in the future. Properties, thickness, width, and tolerances are reviewed. New machines and fabricating processes are discussed.

**Metal Removal — High Temperature Material, reported by R. R. DOBSON, secretary.** Examines five new methods for shaping high temperature and heat-resistant materials. Electrical discharge machining, ultra high speed machining, the chem mill process, abrasive belt machining, and special high-speed steels for machining high-temperature alloys are reviewed.

**Exotic Materials and Processes, reported by H. B. SIPPLE, secretary.** Describes new aircraft, missile, and nuclear materials. New production methods for these materials are examined.

**Test Equipment for Modern Production, reported by V. D. ERICKSON, secretary.** Factory organizational requirements for use and control, cost control, automatic versus manual equipment, the effect of application on end item reliability, integrity assurance, and the education of test equipment operators are examined.

**Low-Quantity and Low-Rate Production, reported by F. F. REED, secretary** Discusses engineering coordination; planning systems and procedures; facilities; personnel placement; labor skills and training; and production scheduling and controls.

**Hole Preparation in Close-Tolerance Work, reported by N. L. SMITH, secretary.** Tells about hole preparation in soft materials (under 150,000 psi) and in hard materials. Also examines available and proposed portable drilling equipment.

**Sandwich Construction — High Temperature, reported by R. R. ROLL, secretary.** Discusses the relative merits of brazed and welded honeycomb sandwich. Examines the properties and testing of sandwich materials. Investigates the design and manufacture of brazing furnaces and tools and discusses future furnace requirements.

## New Developments Broaden Welding Use


Based on talk by

**R. R. MacDONALD**

Precision Welder & Flexopress Corp.


MATERIALS which could not be welded five years ago can now be handled successfully because of advances made in controls. New low inertia heads make possible production welding of aluminum. Furthermore, with the use of a "Wobble Welder" a small diameter (1–4 in.) seam weld can be made in a single plane.

The foil butt seam weld process, a German import, produces welds with physical properties comparable to overlap or mash seam welds. Speeds of 5–20 fpm can be achieved with a minimum increase in joint thickness. This process can be used on mild and stainless steels and because it uses low power and pressure the welding wheels last longer.

Magnetic force welding is now being used to weld vinyl clad steel. The vinyl is unmarked because the process allows the use of a high current and short welding cycle. It is also used as a magna flash welder, producing full area welds up to three-quarters of a square inch. Widest application is in welding contacts to current carrying members in electrical devices. It can be used on ferrous and non-ferrous material.

## Priming Fluid Starts Analyzed


Based on paper by

**J. J. DeCAROLIS**

**and**

**W. E. MEYER**

The Pennsylvania State University

**P. W. ESPENSCHADE***

U. S. Army Ordnance Corps

* Formerly with Engineer Research & Development Laboratories, Ft. Belvoir, Va.


PRIMING fluid, to start a diesel, must be supplied initially at a high rate to keep cranking time short. After the engine has accelerated to warmup speed, the rate should gradually decrease . . . and become zero when the regular fuel will ignite without assistance from the priming fluid. For every temperature-engine combination, a minimum initial rate exists for a start within a given number of seconds.

By direct injection, the cylinders can be provided with priming fluid at the high initial rates required at very low temperatures. But direct in-


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jection means are prohibitively complex and costly.

Spraying fluid into the intake manifold is simplest, but precipitation of the larger spray drops makes it difficult, if not impossible, to deliver enough fluid to the cylinders during cranking. In addition, the fluid accumulated in the induction system during cranking will be rapidly drawn into the cylinders once the engine starts. This leads to overspeeding and possible damage.

These undesirable effects can be somewhat lessened by the priming fluid composition. The most effective practical fluid is diethyl ether. Diluting it with less-volatile, slower-burning materials will improve engine operation after cranking, but dilution of the ether reduces its effectiveness during the crucial cranking period.

A better method is to employ plain ether and supply it to the intake manifold in vapor form. Part of the introduced vapor will condense in the cold intake air and form small droplets that are carried along by the air without difficulty. This means that delivery to the cylinders is positive. They receive ether at the rate at which it is supplied to the manifold, making it easy to provide adequate rates. The difficulties attendant to accumulation of ether in the induction system are prevented.

Improvement in startability can be obtained by vapor introduction of ether. Even with vapor application, however, there is a minimum starting temperature for each engine type. In some cases the minimum temperature can be quite high, indicating that further work must be done if quick starts are to be obtained on all engine types throughout the military temperature range.

**To Order Paper No. 101A . . .** on which this article is based, see p. 6.

## Vapor Lock Problem Grows More Complex

Based on paper by

CHARLES J. BRADY
and
DALE R. JOHNSON

Desert Proving Ground, GMC

LOSS in power, momentary cutout, complete engine stoppage, poor idling, stalling in city traffic, or poor hot starts are highly important because they make car owners dissatisfied. Any one may be a manifestation of the disturbance known as vapor lock, which can result in a thinning or an enriching of the mixture ratio.

A few years ago fuel systems had relatively simple components; today complexity and intricacy rules. Nevertheless, current fuel systems are at least the equal in hot fuel handling performance, during most types of operation, to those on the earlier cars by virtue of overcoming the following:

1. An increase of at least 1 psi in vapor pressure of currently available summer commercial fuels.
2. A higher fuel consumption rate during acceleration because of higher performance engines.
3. Much higher environmental temperatures resulting from the use of air conditioning and pressurized engine cooling systems.

Certain conditions indicate an intensification rather than a decrease of work on hot fueling handling problems. A few of these conditions are:

1. Higher octane fuels can be produced more economically with more volatile ingredients; supplies of these ingredients are adequate, particularly during the summer months.
2. The automobile manufacturer's desire to keep car cost to a minimum, which means an effort to restrict vehicle component cost.
3. The possibility of lowering engine cooling system cost by using increased system pressures for higher efficiency, thus creating higher fuel system en-

vironmental temperatures.

4. The customer's demand for more and more power assist and comfort accessories, which induce heat loads, require mounting room in the engine compartment, and increase the ratio of engine horsepower to wheel horsepower for any given operating condition.

The upshot is that car producers must work more closely with the oil companies than ever before if the customer is to receive a well-balanced fuel system.

**To Order Paper No. 104A . . .**
on which this article is based, see p. 6.

## *Storage Stability of Jet Fuel Object of CRC Study*

THE ability of 32 jet fuels to withstand severe storage conditions is detailed in CRC Report 327, "Jet Fuel Storage Stability." The fuels which represented 14 base stocks from three refining areas were subjected to the following conditions:

- Severe desert storage.
- Average but milder bulk storage.
- Accelerated laboratory storage.

*Under severe desert storage conditions,* the fuels formed soluble gum as follows:

| No. of Fuels | Mg Gum/100 Ml Fuel |
|---|---|
| 19 (Representing 8 base stocks) | < 7 |
| 2 | 7–10 |
| 4 | 10–20 |
| 7 | 20 + |

*Under the same conditions,* these fuels formed insoluble residue as follows:

| No. of Fuels | Mg Insoluble Residue/100 Ml Fuel |
|---|---|
| 20 (Representing 9 base stocks) | 2 |
| 9 | 2–4 |
| 3 | 4 + |

*Under bulk storage conditions,* very little degradation occurred during the 24 months in either the straight run or the partly cracked jet fuel. Insoluble residue content in each case was 0.4 mg/100 ml.

Laboratory storage at 90, 110, 130, and 158 F failed to show any consistent effect of storage temperature and time and on insoluble residue. Lack of uniformity deterred making any generalizations as to the effect of storage temperature and time on soluble gum, although there was a qualitative trend toward higher soluble gum with increasing temperature and time.

A reasonably good correlation exists between the amount of soluble gum formed at the end of 5- or 8-hr accelerated steam jet gum tests and at the end of 19 or 24 months of storage in the desert. Most fuels, 20 out of 32, formed 7 mg or less/100 ml of fuel in the accelerated test as well as in 19 months of storage. Those that formed > 7 mg in the accelerated test also attained this level in 19 months of storage in the desert.

High soluble gum content was definitely related to oxygen absorption in the drums except for Fuel RAF-61-51 which was 100% of catalytically cracked stock. Drums which were not vented did not change appreciably in gum content. Those fuels showing the greater oxygen depletion in the drums between venting periods also were high in soluble gum content.

CRC 327 contains 108 pp. including graphs and charts.

**To Order CRC No. 327 . . .**
on which this article is based, see p. 6.

## Inertial Guidance Made Possible by Fluid Suspension

Based on paper by

**J. STATSINGER**
American Bosch Arma Corp.

(Reported by R. S. Karlson, SAE Southern New England Section Field Editor)

A NEW suspension principle has made inertial navigation practical for aircraft and missiles. It is the fluid immersion technique and has reduced nearly to zero the friction forces that caused errors in previous systems.

A gyroscope and an accelerometer are the heart of inertial guidance. The first provides a stable platform for the second. By integrating the accelerations experienced during flight, the system can give position and velocity at any time. However, any error or drift in the system influences the accuracy of results thereafter. Friction forces on both instruments cause such errors.

Sealing the gyro wheel in a shell and then suspending the shell by fine wires in a larger shell filled with a neutral buoyancy fluid has eliminated the pivot friction encountered in gimbal rings. High accelerations will not cause the gyro shell to move in the fluid because the fluid has the same density as the gyro shell assembly. The wires holding the inner shell do not exert a torque on the inner shell as the outside shell magnetically senses any minute motion of the inner shell and is automatically driven by servo motors to follow it.

The immersion principle is also used to suspend accelerometers. A mass is suspended by a flexible metal tape of low stiffness. An electrical spring supplies the resistive spring force. The surrounding fluid provides viscous damping and shock protection while permitting rapid response to applied accelerations.

**To Order Paper No. S119 . . .**
on which this article is based, see p. 6.



## *Brazed Honeycomb or Welded Corrugations? Each Have Advantages*

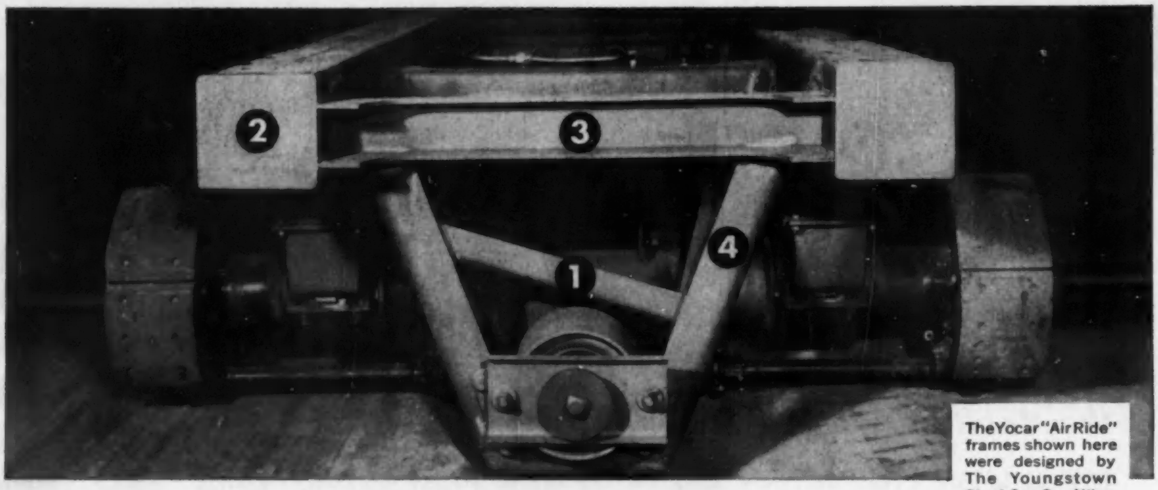
Based on report by secretary

**ROBERT R. ROLL**
Solar Aircraft Co.

THE following comparisons between brazed honeycomb structure and welded corrugated sandwich structure can be made.

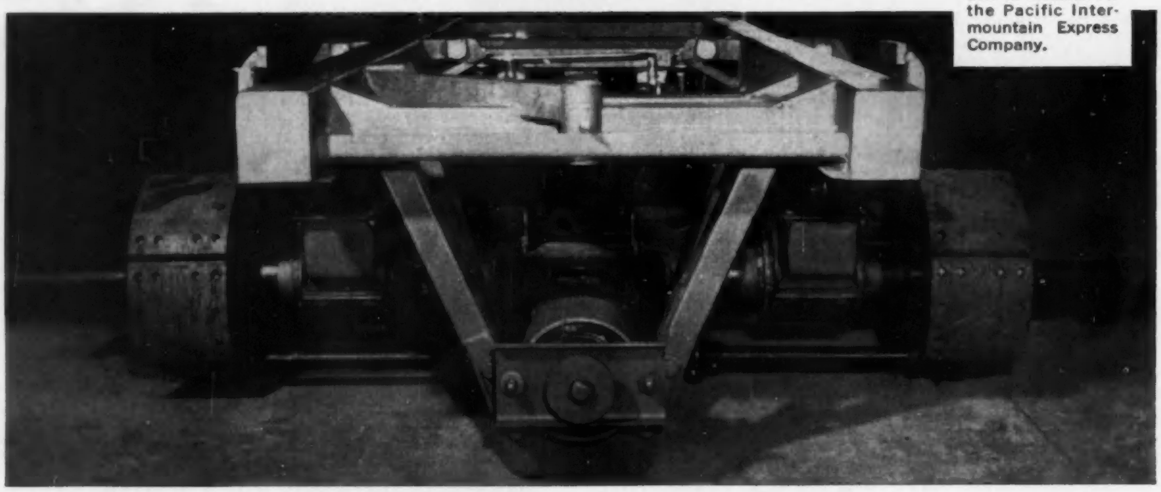
1. Corrugated panels are limited to unilateral loading applications while brazed honeycomb can be subjected to bilateral loading.
2. Both types of sandwich require accurately fabricated detail parts to insure the precise fits required for assembly.
3. Corrugated panels can be inspected readily during welding stages whereas brazed panels after being sealed in a retort cannot be observed.
4. Corrugated panels appear to be more easily repaired than brazed honeycomb panels.
5. Brazed honeycomb structure appears to present less of a fire hazard than corrugated sandwich for integral fuel cell structure.
6. Brazed honeycomb is easier to taper than corrugated sandwich.
7. Brazed honeycomb appears to display a smoother aerodynamic surface and greater buffet resistance.
8. Brazed honeycomb has better thermal insulation properties than comparable strength corrugated sandwich.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: **M. W. Wegeforth,** Solar Aircraft Co.; **Dr. Michael Watter,** The Budd Co.; **Robert P. Roberts,** Twigg Industries;




1,187 lbs.: Standard carbon steel

The Yocar "Air Ride" frames shown here were designed by The Youngstown Steel Car Co., Niles, Ohio, for installation in vehicles for the Pacific Intermountain Express Company.



900 lbs.: Republic "65" High Strength Steel

# New trailer frame assembly weighs 24% less when made from nickel-copper-moly high strength steel

Compare the frame members numbered above. The number 1 frame has been eliminated entirely in the bottom picture. Compare, too, the thinner sections 2, 3 and 4. Each of these sections was reduced in weight when Republic High Strength Steel was used.

**REASON?** This nickel-copper-molybdenum steel has a high strength-to-weight ratio. The Republic "65" high strength steel used in this trailer has the following typical mechanical properties in the as-rolled condition:

| | |
|---|---|
| Yield Point | 67,000 psi |
| Ultimate Tensile Strength | 89,000 psi |
| Elongation in 2 inches | 18% |

**RESULT?** Design engineers can take advantage of these excellent mechanical properties to incorporate thinner and lighter sections with no sacrifice in strength and safety.

Compared to conventional carbon steels, the use of high strength alloy steels results in important weight reduction . . . often as much as 50%.

If you must save weight and want a steel with high strength-to-weight ratio, excellent mechanical properties and superior corrosion resistance, a high strength, nickel alloy steel may be the answer for you, too. Inco will be happy to help you select one that fits your need. Just write.

**THE INTERNATIONAL NICKEL COMPANY, INC.**

67 Wall Street — New York 5, N. Y.

# INCO NICKEL

W. S. Hay, General Dynamics Corp.; V. L. Darby, North American Aviation, Inc.; O. T. Ritchie, Boeing Airplane Co.; John Stansbury, Swedlow Plastics Co.; and H. S. Haag, Rohr Aircraft Corp.

(This article is based on a secretary's report of a production panel entitled "Sandwich Construction — High Temperature." This report — along with 10 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-325. See order blank on p. 6.)

## Secondary Discharge Voltage Not Cut by Preionizing Gap

Based on paper by

J. J. GUMBLETON

General Motors Corp.

PREIONIZING the spark-plug gap with radioactive gold-198 does not reduce secondary spark discharge voltage, a recent investigation disclosed.

Conclusions reached were:

- Naturally produced thermal electrons at high engine operating temperatures and pressures cause sufficient ionization to saturate the spark gap with ions. Further ionization cannot be produced by an artificial radioactive source.
- Reduction in beta particle range at high engine operating pressures is not sufficient to cause a decrease in beta ionization.

To Order Paper No. 8T . . .
on which this article is based, see p. 6.

## Save the Small Engine—Adhere to PM Schedules

Based on paper by

WALTER KLAUSER

Thermo King Corp.

THE tendency for carbon deposits to form and cause trouble in utility engines requires strict adherence to preventative maintenance schedules if maximum life is to be obtained from the engine.

The following maintenance operations should be performed at the specified intervals to insure the most efficient service from the unit.

**Every 50 operating hours**

Change engine oil while the engine is hot.
Clean and refill carburetor air cleaner.
Clean and refill crankcase air cleaner.

**Every 200 operating hours**

Clean the unit thoroughly.
Inspect mounting bolts on engine.
Test and clean batteries.
Inspect battery hold downs.
Inspect battery terminals.
Clean or replace spark plugs.
Inspect and adjust ignition points.
Clean and inspect distributor cap and ignition wires.
Check the automatic choke operation.
Check the cooling system.
Check the ignition timing.
Check fuel pump pressure.
Check the carburetion using a combustion analyzer.
Check the charging rate.
Check the engine operating speed.
Make the 50 hour checks listed above.

**Every 400 operating hours**

Inspect needle valve and seat of the carburetor, reset float level.
Make all the 50 and 200 hour checks listed above.

**Every 800 operating hours**

Check compression pressure
Make all the 50, 200, and 400 hour checks listed above.

To Order Paper No. 97B . . .
on which this article is based, see p. 6.

## Obituaries

**HENRY F. BICKERSTAFF** . . . (A'47) . . . general manager of Joseph L. Bickerstaff's Sons . . . died October 28 . . . born 1904.

**HAROLD F. BLANCHARD** . . . (M'25) . . . had been technical editor of "Motor" and manager of the book department of that magazine . . . died December 29 . . . born 1890.

**C. S. CARSWELL** . . . (A'46) . . . lubrication engineer with McColl-Frontenac Oil Co. Ltd. . . . died March 23 . . . born 1893.

**COL. MATTHEW J. FARRELL** . . . (M'14) . . . engineer, production, Department of the Army, Philadelphia Q. M. D. . . . died November 23 . . . born 1881

**JAMES R. FLUENT** . . . (M'53) . . . design engineer with Aeron Nutronic Systems, Inc. . . . died August 13 . . . born 1911.

**WILLIAM J. FOSTER** . . . (M'17) . . . regional business manager, Chevrolet Motor Division of General Motors Corp. . . . died December 5 . . . born 1891.

**RALPH J. FURSTOSS** . . . (M'53) . . . manager, vehicle section, Central Engineering Division of Caterpillar Tractor Co. . . . died December 23 . . . born 1912.

**WILLIAM T. HARRISON** . . . (M'57) . . . factory manager, Bendix Products Division of Bendix Aviation Corp. . . . died April 10 . . . born 1903.

**SAMUEL P. HESS** . . . (M'18) . . . had been sales manager, Spring Division, of Detroit Steel Products Co. . . . died October 24 . . . born 1885.

**WILLIAM L. MYERS** . . . (M'51) . . . president, general manager of Zol-Con-Add of Ohio . . . died July 16 . . . born 1901.

**JOHN D. NOTHSTINE** . . . (M'52) . . . president, mechanisms, research and design of Astec Engineering Co. . . . died November 29 . . . born 1916.

**NORMAN O. PANZEGRAU** . . . (M'31) . . director of defense operations, The Oliver Corp. . . . died October 2 . . . born 1898.

**ANDREW RAFFAY, JR.**, . . . (M'41) . . . manager — original equipment manufacturer sales, Chicago office of PurOlator Products, Inc. . . . died November 13 . . . born 1904.

**BEN D. SMITH** . . . (M'55) . . . was master mechanic, manufacturing research with International Harvester Co. . . . died September 14 . . . born 1906.

**J. RUSH SNYDER** . . . (M'43) . . . project engineer, Thompson Products, Inc. . . . died August 31 . . . born 1886.

**ALFRED L. STEM** . . . (M'51) . . . supervisor, chassis drafting, Ford Division of Ford Motor Co. . . . died October 13 . . . born 1895.

**FRED L. SUMSER** . . . (M'57) . . . director of maintenance with Haeckl's Express, Inc. . . . died October 1 . . . born 1907.

**HAROLD SYDNOR** . . . (M'54) . . . assistant general manager, manufacturing, Esso Standard Oil Co. . . . died November 26 . . . born 1898.

**WILLIAM W. WIGHT** . . . (M'57) . . . chief metallurgist with Cooper Alloy Corp. . . . died June 16 . . . born 1912.


# letters from readers...

*From:*
Prof. A. L. W. Seyffardt
Van Doorne's Automobielfabriek N.V.
Eindhoven, Netherlands

*Dear Editor:*

With some astonishment I read in your November issue on page 31 the following announcement:

*"1st All-Netherlands Car under way:*

"Over at the Hague, it appears, the first all-Netherlands passenger car is in the making. It is being produced by Van Doorne's Automobielfabriek, who has for many years assembled Chrysler products in the Netherlands."

If we forget the old "Spijker" (which is now only a gem in veteran car clubs), our factory will indeed produce the first all-Netherlands car since many years. Our factory is, however, situated in Eindhoven, which compares with the Hague, like Detroit compares with Washington. We never assembled Chrysler products. As a matter of fact Chrysler products were never assembled in Holland.

Our company was founded in 1928 and started construction of trailers in 1930. It developed into one of the largest trailer factories of Western Europe. In 1950 a truck factory was founded, which now has a production of about 6000 trucks a year for civil and military use. In 1957 a new engine plant was inaugurated, which is producing diesel and gasoline engines for commercial vehicles.

A small car (DAF-600) with a 600 cc twin cylinder 4-stroke boxer type engine was exhibited at the Automobile Shows in Amsterdam, Paris, and London last year and will come into production early this year. It is the first low-priced small car with fully automatic transmission, called "Variomatic" drive. Production is planned at a rate of 200 cars a day in one-shift work.

• ——— •

*From:*
P. Bruijn, Adjunct-directeur
Rijksautomobielcentrale
Voorburg, Netherlands

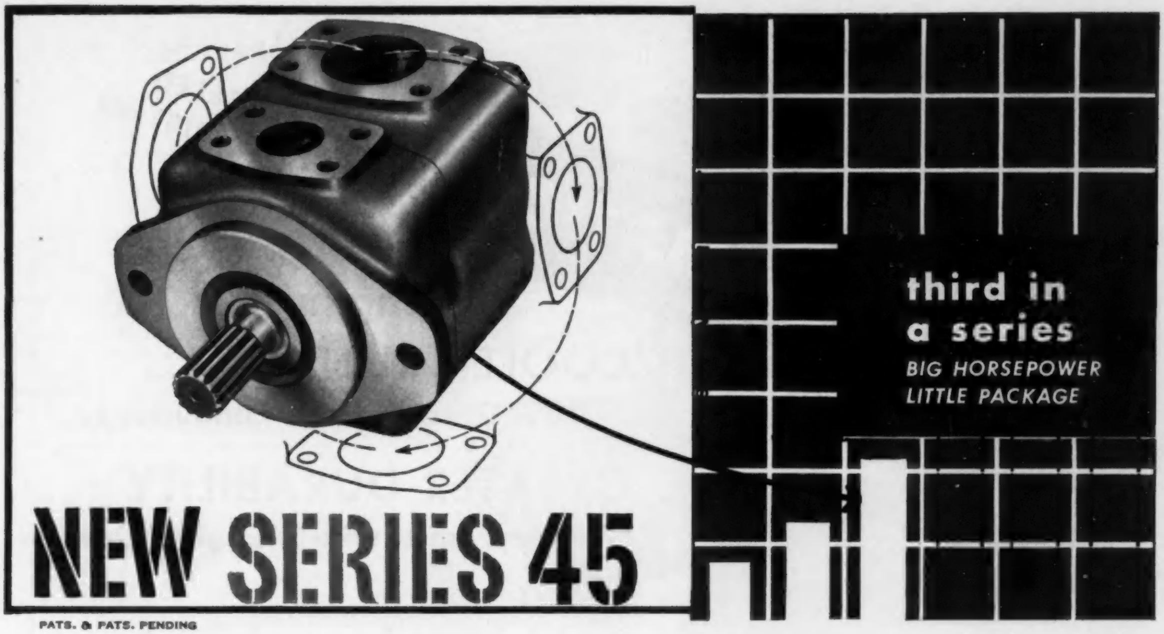
*Dear Editor:*

. . . (Your readers might also be interested to know that) Chrysler cars have been assembled in Antwerp, Belgium, since about 1930 by the Société Anonyme Chrysler.

Since November 1958 this assemblage has gradually been transferred to Rotterdam, Holland, where it is effected in the assembling plant that was taken over by Chrysler Corp. from Kaiser-Frazer.

• ——— •

continued




PATS. & PATS. PENDING

# VICKERS® "high performance" vane pump

## • high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . much more horsepower than previous pumps of the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all operating speeds assures efficient operation at increased speeds and pressures.

NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

NEW 2-BOLT MOUNTING (SAE 1959 STD.).

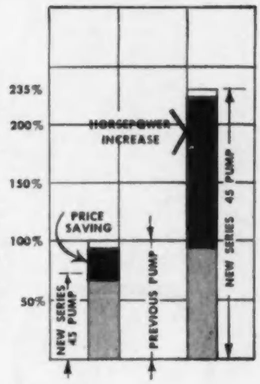
NEW 4-POSITION COVER . . . outlet can be rotated in 90° increments with respect to inlet.

NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.

### MUCH MORE HORSEPOWER PER DOLLAR

The striking increase in horsepower per dollar of the Series 45 over previous pumps of the same delivery capacity is shown in the graph to the right. Maximum horsepower is more than double (235%) and price is lower by 35%.

This is the third unit released in the new complete line of "High Performance" Pumps, single and double. The first (Series 25) is available in 12, 14 and 17 gpm sizes and the second (Series 35) comes in 21, 25 and 30 gpm sizes (at SAE rating of 1200 rpm and 100 psi). This new Series 45 pump is available in 35, 42 and 50 gpm sizes.




*The table below shows characteristics*

| Model Number | Delivery—gpm 1200 rpm 100 psi | Delivery—gpm 2000 rpm 2000 psi | Input Horsepower @ 2000 rpm 2000 psi | Package Size† | Weight |
|---|---|---|---|---|---|
| 2V35A-1*10 | 34 | 52 | 71 | L. 7¾" W. 6¼" H. 6½" | 69 Lbs. |
| 2V42A-1*10 | 41 | 63 | 86 | | |
| 2V50A-4*10 | 48 | 75 | 103 | | |

†Exclusive of Shaft Extension and Mounting Lobes

8201

*Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.*


**VICKERS INCORPORATED**
DIVISION OF SPERRY RAND CORPORATION

**Mobile Hydraulics Division**
**ADMINISTRATIVE and ENGINEERING CENTER**
**Department 1440 • Detroit 32, Michigan**

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (EL Segundo) • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA
ALSO SOLD AND SERVICED IN AUSTRALIA, ENGLAND, GERMANY & JAPAN
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto, Montreal & Vancouver


**ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921**

## letters from readers...

. . . continued

*From:*
Allister Ingham
Ingham Motor Toboggans
Saskatoon, Sask., Canada

*Dear Editor:*

We are at present experimenting on a rotary type of internal combustion engine, and would appreciate any information you could give us on articles which may have been published in SAE Journal on this subject.

*(A check of SAE Journal Indexes shows that there are two papers — both by E. S. Hall — one in the October, 1930, issue, and one in December, 1940, on this subject.*

*(Incidentally, SAE Journal Index for the calendar year is now bound in at the end of the December issue. —* ***Editor)***

*From:*
James T. Moore
American Motors Corp.
Detroit, Mich.

*Dear Editor:*

For many years I have read your capsule editorials entitled "For the Sake of Argument." The penetrating clarity of appropriate thought behind each piece makes them little masterpieces of the written word.

Why don't you collect what you consider to be the best and publish them in book form?

*(About 100 of these editorials were published in 1947 in a book titled "Getting Along with Others in Business."*
***— Editor)***

*From:*
George H. Moore, Chairman
Editorial Committee
Engineering Society of Detroit, Inc.
Detroit, Mich.

*Dear Editor:*

As part of our program of personal and professional development, the Junior Section of The Engineering Society of Detroit makes available to its members, on a semimonthly basis, important contributions from the current literature.

The editorial "Forget . . . Or Never Know?," in the October, 1958, issue of the SAE Journal, has been selected by our editorial committee for possible distribution and we should like to obtain your permission to copy it. We would mimeograph 300 copies of the editorial and distribute them by mail to our members. No charge would be made for any of the copies, and credit to our source would be given.

We feel that the young engineers who make up our membership will benefit from reading this editorial and hope that we may have your permission to copy it under the conditions stated above.

*(Permission was granted. —* ***Editor)***

## New Members Qualified

These applicants qualified for admission to the Society between December 10, 1958, and January 10, 1959. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

**Baltimore Section**

William Anderson (J).

**Canadian Section**

Winston C. A. Hay (J), J. Barton Lewis (M), James Edward Scranton (J).

**Central Illinois Section**

William G. Dixon (J), Glen A. Glover, Jr. (J), Walter H. Lenz (M), Shairyl I. Pearce (J), Carl J. Szentes, Jr. (J), William R. Thomas (M).

**Chicago Section**

George F. Boltz (M), Theodore O. Elsner (M), Paul H. Harrer (M), Richard William Kenngott (J), William Mikulas (M), John L. Perkins, III (A), Philip J. Peterson (J), Joseph D. Raczek (M), Frank J. Simak (J), John C. Straub (M), Edward A. Swanson (A).

**Cleveland Section**

Abe J. Hanje (M), Clark H. Hofmann (J), John R. Hydock (J), Erwin Edward Kempke, Jr. (J).

**Dayton Section**

Richard J. Becht (M), James William Miller (J), William Frederick Schmitz (J), Ferdinand M. Trobridge (M).

**Detroit Section**

John C. Campbell (M), Kenneth L. Clark (J), Stanley O. Cook (J), Peter M. Dawson (J), Roger L. DeMumbrum (J), David R. Engstrom (J), Vincent E. Flaherty (M), Peter Henry Foss (J), Karl E. Gierman (M), Richard D. Kendall (J), Leanard M. Kovacheff (M), Robert W. Kroepel (M), Throck M. Lowery (J), Albert G. Lucas (J), George E. Mayhew (A), John McDougall (M), William Patrick Nelson (J), P. A. O'Connell (A), Raymond Norman Okonski (M), Charles D. Parker (J), Joseph V. Pielecha (M), Alexander P. Podges (M), William A. Rasor (J), Norman Revenaugh (M), George J. Rumford (J), Eugene L. Scala, Jr. (J), Edward B. Sturges, 2nd (A), Alan Thebert (J), Walter Torbet (J), Richard J. Vansen (J), David W. Vial (J), Howard F. Voigt (J), John H. Warren (J), Clinton Todd Washburn (J), Robert D. Wilson (M), Eugene George Zipp (J).

**Hawaii Section**

Edwin Cabral (A), Cecil S. Carmichael (M).

**Indiana Section**

James E. Long (J), Allan Scott Norris (J), William Lloyd Ratts (M), Donald M. Riley (J), William A. Vincent (J), D. A. Weaver (M), Edward M. Wene (M).

**Metropolitan Section**

B. A. Certo (M), Maths Gradin (M), Paul P. Rosenfeld (J), Fredrick L. Schaller (A), Fred B. Silvan (A), T. A. Weiss, Jr. (M).

**Mid-Continent Section**

Nathandale Farris (J), John F. Mason (M).

**Mid-Michigan Section**

Roland J. Lescelius (J), William P. Pautke (M).

continued

## New Members Qualified

Continued

**Milwaukee Section**

Gerald W. Bernhoft (J), John Stuart Eid (M), Thomas M. Garvey (M), Howard G. Halvorsen (A), Jerome J. Schleis (J), Milton A. Suckow (M).

**Montreal Section**

Anthony Alexander Newbury (A), T. George Oates (A).

**Northern California Section**

Kazumi Abe (J), Lawrence E. Atwood (A), Richard H. Ferry (J), David Kroger Homan (A), Joseph Meyers (A), Robert B. Rubsamen (A), Eugene D. Sweetland (M).

**Northwest Section**

Gerrit William Elsinga (J), James Monroe McGee (M), Gonzalo Tornell, Jr. (J), Kenneth G. Winter (J).

**Philadelphia Section**

Russell E. Klinger (M), Julius Samuel (A), Donald H. Thomas (J).

**Pittsburgh Section**

William Allen Heinecke (J).

**St. Louis Section**

John S. Coon (M), William John Murray (J), Louis John Polaski (J), Geoffry Wallar Smith (J), George Franklin Wright (J).

**Salt Lake Group**

George L. Jensen (J), Rex Dwane Matesen (J).

**San Diego Section**

Emmet Howard Christensen (J), Richard L. Lewis (J), Wesley T. Shipway (J), Guy Andrew Vince (J).

**Southern California Section**

Michael L. Bower (J), James Chew (J), John Calvin Closson (J), Eldon George Cutler (J), Wendell F. Deeter (M), Charles L. Dummer (J), Francis Eshleman (J), Marvin J. Feuer (J), Allen H. Fink (M), Sheldon Hyman (M), Richard H. Luberacki (J), Harry Michael Reid (J), Robert J. Sampson (J), Edward Andrew Scheb (A), Avery Sloan (J), Ray Mace Smith (J), Hugh Morgan Stilley (M), Grant E. Trettel (J), James P. Woolley (J).

continued

## New Members Qualified

Continued

**Southern New England Section**

Richard G. Bartram (J), Gerald F. Crowley (J), David Bernard Scott (M).

**Spokane-Intermountain Section**

Harold J. Borneman (M), Kenneth E. Nicholson (A).

**Texas Section**

C. H. Rose (M), Darol D. Travis (M).

**Texas Gulf Coast Section**

Robert E. Pate (J).

**Twin City Section**

William Louis Bruggeman, Jr. (M), E. M. Nelson (M), Norman F. Wulf (M).

**Western Michigan Section**

Harvey J. Meeusen (J).

**Outside Section Territory**

Glenn R. Bishop (M), John Curnan (M), Myron E. Fredenburg (J), H. G. Gilchrist (J), George R. Jedlicka (J), Ralph Ernest Jennings (J), Jerrold R. Owens (J), John S. Phelps (M), Warren O. Simpson (M).

**Foreign**

Philip Charlton (M), New Zealand; Major V. P. Gulati (M), India; Claude Hill (M), England; Alfred Xavier Napoles (A), Cuba; Clifford G. Waterbury (A), Costa Rica.

## Applications Received

The applications for membership received between December 10, 1958 and January 10, 1959 are listed below.

**Atlanta Section**

Charles M. Jones.

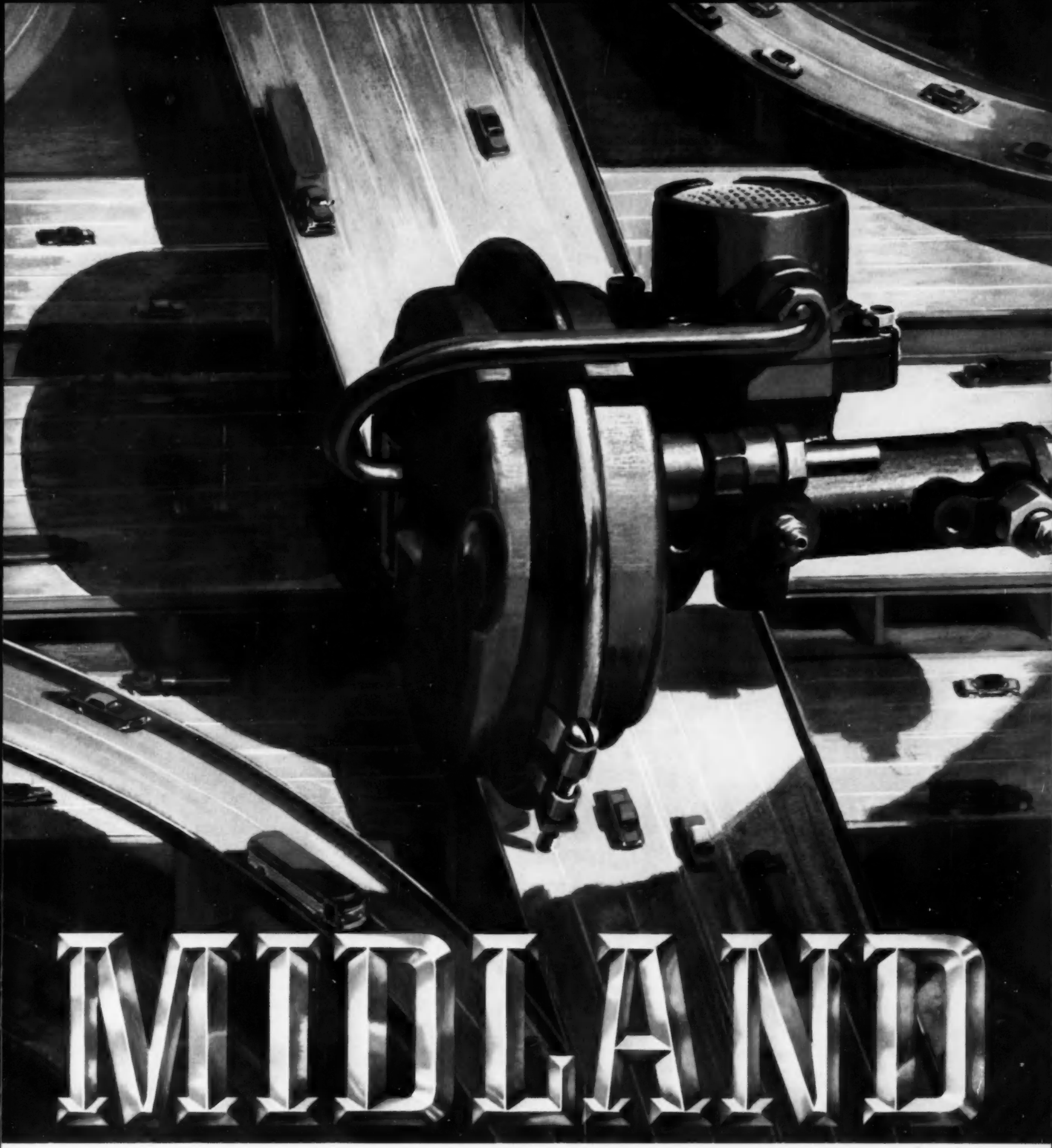
**British Columbia Section**

Beverly Ian Davis, Alfred Edwin Mitchell.

**Buffalo Section**

Gabriel V. Pesce.

continued


MIDLAND

# IMPROVED CHARACTERISTICS

...OF SPECIAL INTEREST TO AUTOMOTIVE ENGINEERS

# DELCO HIGH POWER TRANSISTORS


## UNEXCELLED FOR SWITCHING, POWER HANDLING, EFFICIENCY, RELIABILITY

TYPICAL CHARACTERISTICS AT 25°C.

| | 2N1100† | 2N1099‡ | 2N174A* | 2N174 | 2N173 | 2N278 | 2N277 | 2N443 | 2N442 | 2N441 |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Collector Current | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 amps |
| Maximum Collector Voltage (Emitter Open) | 100 | 80 | 80 | 80 | 60 | 50 | 40 | 60 | 50 | 40 volts |
| Saturation Resistance | .02 | .02 | .02 | .02 | .03 | .03 | .03 | .03 | .03 | .03 ohms |
| Thermal Gradient (Max.) (Junction to Mounting Base) | .8 | .8 | .8 | .8 | .8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 °C/watt |
| Base Current $I_B$ ($V_{EC}$ = 2 volts, $I_C$ = 5 amps) | 135 | 100 | 135 | 135 | 100 | 100 | 100 | 150 | 150 | 150 ma |
| Collector to Emitter Voltage (Min.) Shorted Base ($I_C$ = .3 amps) | 80 | 70 | 70 | 70 | 50 | 45 | 40 | 50 | 45 | 40 volts |
| Collector to Emitter Voltage Open Base ($I_C$ = .3 amps) | 70 | 60 | 60 | 60 | 50 | 45 | 40 | 55 | 45 | 40 volts |

*Designed to meet MIL-T-19500/13A (Jan) 8 January 1958 †Formerly DT100 ‡Formerly DT80

Check your requirements against the *new, improved* characteristics of Delco High Power transistors. You will find improved collector-to-emitter voltage . . . higher maximum current ratings—15 amperes, and extremely low saturation resistance. Also, note the new solid pin terminal design.

*And of special importance to you is the fact that diode voltage ratings are at the maximum rated temperature (95°C.) and voltage.*

Write today for engineering data on the *new, improved* characteristics of *all* Delco High Power transistors.

# DELCO RADIO

**Division of General Motors · Kokomo, Indiana**

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

## Applications Received

Continued

**Canadian Section**

Ralph Warren Biggar, Tibor Dancs, Nicholas G. Grabb, John William Lambert, Ian Fraser Steven.

**Central Illinois Section**

Gary Oren Bragg, Walter David Cashman, Robert Leon Hillyer, Albert Edward Rust.

**Chicago Section**

Richard W. Hurckes, Myron A. Jones, Robert C. Miller, William A. Shields, George P. Scelzo.

**Cincinnati Section**

William J. Brown.

**Cleveland Section**

John O. Antonson, Frank W. Bowers, Harvey A. Cook, Gilbert H. Graham, Loy David Jones, Wallace L. Pepin, S. T. Salvage.

**Detroit Section**

James E. Collins, William H. Corba, Antonio Carlos A. Costa, George P. Holman, William H. Houghton, George Ilich, Norman W. Johnson, Rolland E. Kontak, Ernest S. Kratzet, James R. LeRoux, Thomas J. McKey, Walter R. Opel, Roger Rafael Regelbrugge, Leo E. Sanker, Donald F. Tripp, James W. Watson, Donald J. Welter, Kenneth H. Woodrich.

**Indiana Section**

George C. Brainard, Jr., Charles W. Davis, James H. English, Tobi Goldoftas, Verle E. McCarty, Kenneth R. Moore, Robert D. Morss, Rodney Lee Wallace.

**Metropolitan Section**

Hermann Bruns, Joseph M. Burrows, William F. Connell, Daniel James Gallagher, William I. Graham, Martin T. Mobach, Lindsay Payne.

**Mid-Michigan Section**

Robert J. Christensen, Kenneth R. Engelmann, William H. Knapp, Robert C. Oakes.

**Milwaukee Section**

Joseph P. Plevak, Charles L. Salkowski, James S. Scott, Jr.

**Mohawk-Hudson Section**

William Meaney.

**Montreal Section**

Lionel Chartrand

**Northern California Section**

Bernard S. Greensfelder, James F. Wellington.

**Philadelphia Section**

Ralph G. Rutman

**Pittsburgh Section**

Elias Malichky, William McCune, Richard W. Twigg.

**St. Louis Section**

R. O. Tuegel.

**San Diego Section**

Walter A. Harney, M. V. Rama Rao, F. Q. Wilson

**Southern California Section**

John Paul Davis, William J. Kennedy, George G. McKhann, Jr., Daniel D. Monaco.

**Southern New England Section**

Harry J. Hermann, Jr., Donald E. Manning.

**Spokane-Intermountain Section**

Gordon F. Paul.

**Texas Section**

J. W. Mooney.

**Texas Gulf Coast Section**

Clarence D. Anderson, Richard A. Geer, LeRoy C. Laycock.

**Twin City Section**

Harry M. Hermanson, Walter William Klausler, Dwayne Arthur Rule, J. Philip Soderstrom.

**Washington Section**

Thomas E. Weber.

**Western Michigan Section**

Dan L. Olsen.

**Williamsport Group**

Sanford Epstein.

**Outside of Section Territory**

Lynn C. Brendel, Leonard Dexter, Maxwell Eaton, Sr.

**Foreign**

Peter K. L. Arnold, New Zealand; Sayed Bayoumi, Egypt; Giorgio Geddes da Filicaia, Italy; Jawahir Lal Dhar, India; Ahmed Mohmed El-Hariri, Egypt; F. W. Mead, South Africa; S. G. van Hoogstraten, Holland; William B. Watkins, New Zealand.

# FILTOSEAL


## ...THE ONE PIECE FILTER-TYPE LIP SEAL

**This new IPC lip type oil seal neatly combines the correct synthetic compound, for *your* application, with a built-in felt and rubber filter — complete with case in one compact assembly.**

• • •

The bonding of felt to rubber ensures far better seal performance when abrasive particles or other foreign matter are likely to be encountered. IPC's "FILTOSEAL" protects the seal lip from being buffeted, worn or damaged.

By using a *custom* approach to case design IPC engineers can frequently eliminate the need for separate parts which add to assembly costs or maintenance problems. *More,* "FILTOSEAL" can provide adequate seal lip lubrication by incorporating a cavity for preloading lubricant.

Here is a *combination workhorse.* "FILTOSEAL" will answer more problems involving abrasive conditions than anything you've seen so far *and, do it all in one compact unit!* Let's hear about your lip type seal applications. We'll be happy to make a recommendation.

IPC

OIL SEALS / PACKINGS / PRECISION MOLDING
*Custom designed . . . for your application.*

***INTERNATIONAL PACKINGS*** CORPORATION
Bristol, New Hampshire

P1

# THIS MUCH DIRT CAN RUIN A DIESEL ENGINE

# THIS PUROLATOR FILTER

# STOPPED <u>THIS</u> MUCH DIRT

Diesels can't escape abrasive dirt . . . and it takes about 8 ounces of it to ruin an engine.

The 18 pounds of dirt shown above were stopped by a Purolator heavy duty dry type air filter on a rock drilling rig in 940 hours of operation—with no servicing of the filter required. The 6 cylinder, 2 cycle engine and the 750 CFM compressor used on the job were fully protected through the toughest operating conditions. 18 pounds of dirt were stopped . . . none got through the filter.

There's a Purolator dry type air filter designed to meet the specific requirements of your operation. Write today for full information. If you have a particularly tough problem, describe it . . . Purolator has the solution.

*Filtration For Every Known Fluid* **PUROLATOR**
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

# Gears...

*for making molehills out of mountains*

It is hard to imagine worse working conditions, and that is the very reason why the manufacturers of so many kinds of road building equipment install "Double Diamond" gears. Wherever the going is especially rough, wherever gears must give uninterrupted service on harsh, time-table schedules, you'll find our gears at work.

For low installed cost, for true operating economy and performance, and for buckling down to the hardest kind of service—nothing beats "Double Diamond."

Our salesmen are experienced gear engineers. Why not talk to one about your gear requirements?

May we send you a copy of this comprehensive catalog on the many gear types in which we specialize?

**EATON**

**AUTOMOTIVE GEAR DIVISION**
**MANUFACTURING COMPANY**
**RICHMOND, INDIANA**

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS


## New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service, a-c or d-c.

Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . distortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. SA2, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

# New Holley '59 Carburetors can be serviced in minutes—

# WHILE ON THE ENGINE!

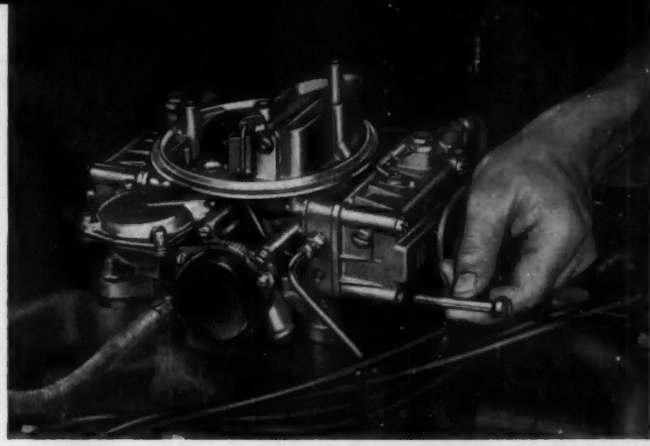
Many 1959 automobiles and trucks will be equipped with newly designed Holley two and four barrel carburetors that have a special needle and seat assembly which makes carburetor service a matter of minutes.

All carburetor minor repair—90% of carburetor service requirements under 30,000 miles—can be completed in the time it takes to remove and replace a single spark plug; and, without removing the carburetor from the engine.

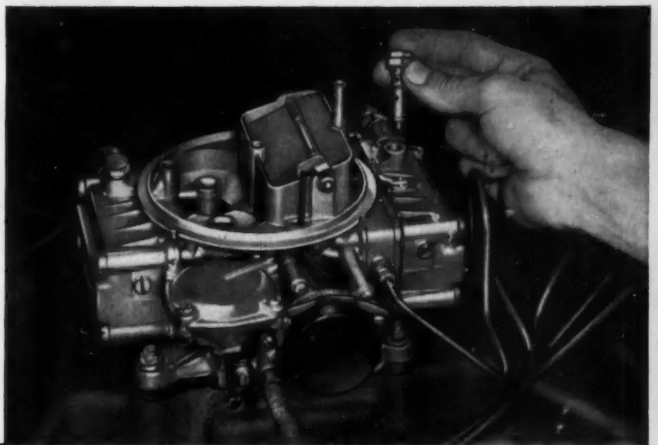
These Holley 1959 models will substantially reduce customer service complaints and will make minor repair work more profitable and more accurate for the service man. With just the four simple steps shown on this page service men can:

1. Purge the carburetor of dirt and foreign matter.
2. Accurately adjust the fuel level in the bowl.
3. Replace or adjust the fuel inlet needle and seat.

These new 1959 carburetors are another example of Holley's continuing leadership in the design and engineering of fuel and ignition equipment.



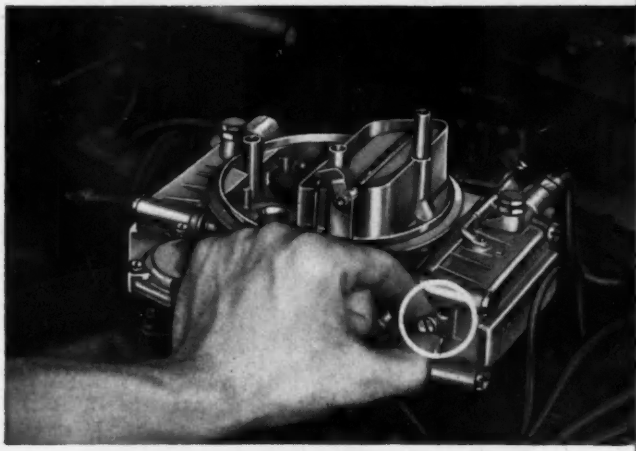
**1** *With ignition off, remove lower bowl screw farthest from fuel inlet. Allow all gasoline to drain, purging the carburetor of dirt and sludge.*



**2** *Remove fuel needle and seat and examine for wear and general condition. Replacement can be made at low cost although there should be no evidence of wear until after 20,000 miles.*

**3** *With engine running, remove sight plug from carburetor bowl opposite fuel inlet. If fuel level is too high, excessive fuel will drain through sight plug opening. For proper operation, fuel level should be on line with threads at bottom of sight port.*

**4** *Loosen top lock nut on needle and seat assembly and adjust with lower nut until float maintains fuel at desired level. Tighten lock nut and minor repair is completed.*



HOLLEY Carburetor Co.

For more than half-a-century — original equipment manufacturers for the automotive industry

11955 E. NINE MILE ROAD • WARREN, MICHIGAN


"Stromberg Carburetor performance builds car owner loyalty every day"
"Sure . . . an owner could easily switch to another make car just because he's been having carburetor trouble. In cases of starting and stalling difficulties . . . and disappointing gas mileage—the average car owner blames the carburetor. And the car manufacturer gets a 'going over', too."
"You're right, Bill, so why take chances with anything but the best in carburetors? And, for over forty years, that's been STROMBERG*. It's built by the leaders in automotive fuel systems—Bendix-Elmira."
*REG. U. S. PAT. OFF.
Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, NEW YORK
Bendix
AVIATION CORPORATION

# DYNAMIC DIFFERENCE

## in hydraulic performance

# Webster

## DIRECTIONAL CONTROL VALVES

Combines to culvert cleaners — anywhere one, two or more hydraulic applications are handled at one time ... *the difference is dynamically apparent when Webster is on the job!* Versatile! Parallel design permits control of up to 6 independent circuits. Range! Operating pressures to 2000 psi — shock pressures to 5000 psi. Lowest back pressure. Compact! Smallest size for rating. Three sizes — single spool type in 20 gpm capacity, parallel stacked in 20 and 40 gpm capacities.

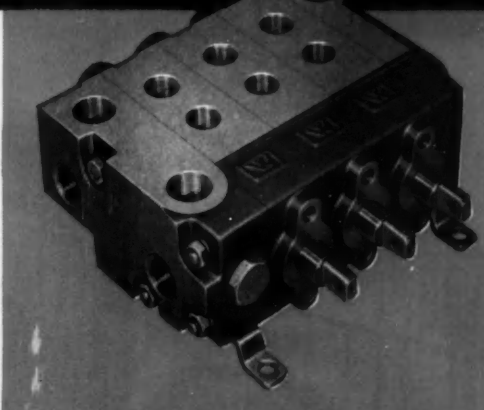
You find Webster Directional Control Valves on leading agricultural, road building and industrial machines. Chances are there's a size and model ideally suited for your product — for the dynamic difference that pays!

**OIL HYDRAULICS DIVISION**

**WEBSTER ELECTRIC**

**RACINE · WIS**

*our 50th year*



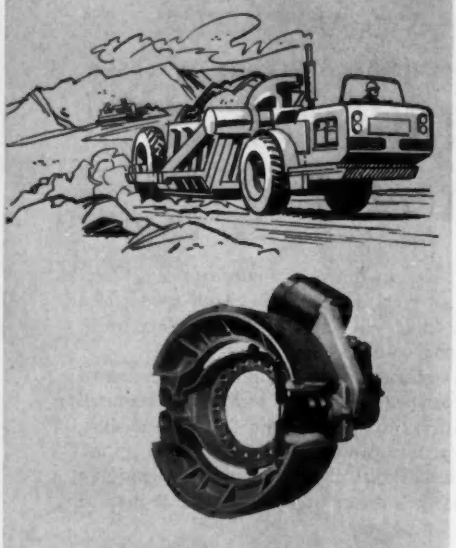
**DESIGNED FOR PEAK PERFORMANCE**

- Alloy steel spools — heat-treated, precision-ground.
- Fully balanced at all pressures.
- Stock valves have throttling grooves in spools for smooth, gradual flow.
- Inlet and outlet connections can be made to the same end of the valve assembly to simplify hook up.
- Alternate porting positions provided for flexibility in application.

***Call the man from Webster***

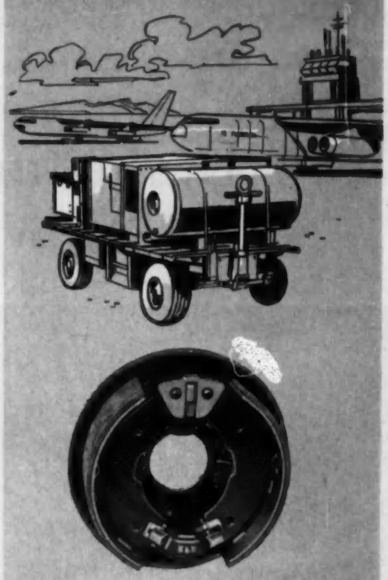
*... he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!*

**BULLETIN HY1** *gives complete performance and installation data.*



**Heavy-Duty "P" Series Air Brake** . . . offers better control, greater dependability, longer service for heavy-duty off-highway applications. Unit mounted design for compactness. Open-type spiders for lower operating temperatures and longer liner life. Wide range of capacities and sizes.

**"DLM" Series Mechanical Brake** . . . primarily a parking brake for trucks, buses, cranes and shovels, it also is ideal for use on farm equipment, hoists, lift trucks and other applications. Self-energizing two-shoe design. Only 8 parts with interchangeable shoes and springs. No lubrication required.



**"DM" Duplex Mechanical Brake** . . . for farm equipment, special-duty utility trailers, light-duty highway trailers and industrial machinery. Two identical shoes do an equal amount of work in either forward or reverse direction. Positive braking with immediate response. Simple design for low maintenance.

# A MATCH FOR ANY MOVING POWER...

# ROCKWELL-STANDARD BRAKES!

Whatever the size or type of brake you require . . . whether it's for an industrial, agricultural, construction, or automotive application . . . Rockwell-Standard's complete line offers a brake that is specifically designed for your purpose.

Products of over 40 years of leadership in brake design and manufacture, Rockwell-Standard Brakes assure the ultimate in safety, dependability, and trouble-free long life. Only Rockwell-Standard combines brake designing, engineering, testing and manufacturing in one integrated facility, to bring you the industry's most advanced brake products.

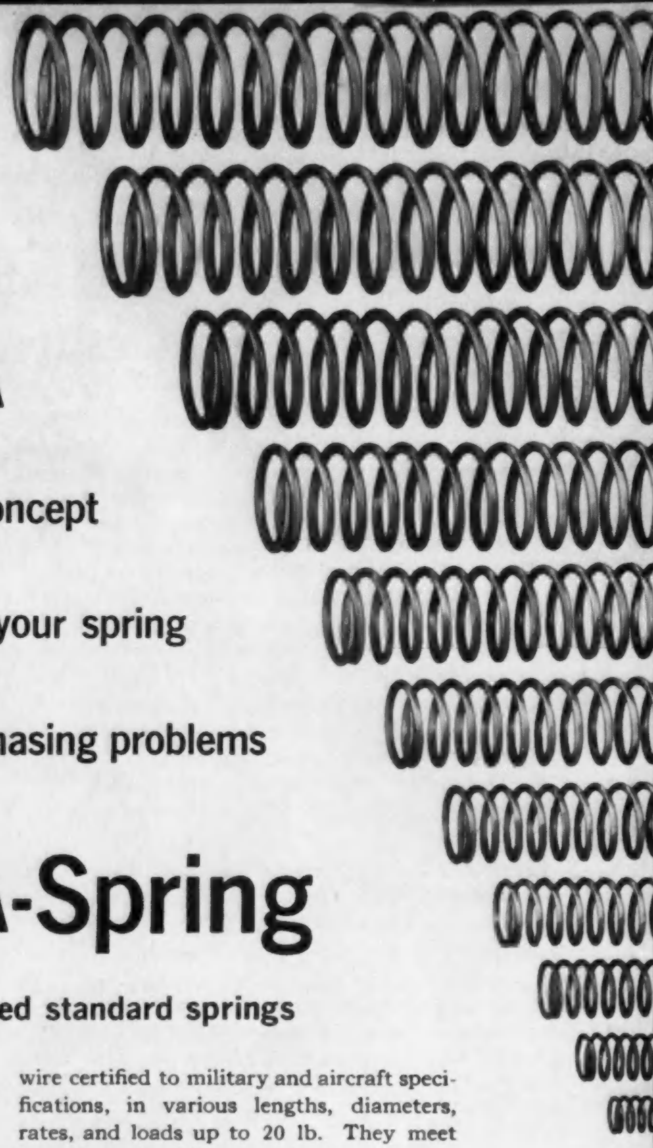
Every Rockwell-Standard brake design has been proven by rigid tests, both in the laboratory by trained technicians, and over thousands of miles of demanding road trials. It's just one more reason why you can be sure . . . your *best* brake is Rockwell-Standard!



ROCKWELL R STANDARD

**ROCKWELL-STANDARD CORPORATION**

BRAKE DIVISION | Ashtabula, Ohio



# A new concept to simplify your spring design and purchasing problems

# Select-A-Spring

## ready-to-use engineered standard springs

Now you can select compression or extension springs from hundreds of ready-to-use, engineered standard-specification sizes. No fuss or paper work—no blueprints or drawings necessary. Select-A-Spring enables buyer or designer to pinpoint his needs without delay. Simply match your requirements to the Select-A-Spring list, order by catalog number, quantity and material. Especially convenient where quantities are moderate.

Select-A-Springs are pre-engineered, using wire certified to military and aircraft specifications, in various lengths, diameters, rates, and loads up to 20 lb. They meet industry and military standards. Material is either music wire or stainless steel. Compression springs are squared and ground. Extension springs have regular loops. Other ends and loops optional.

*Whether your need is immediate or future, write now for the A.S.C. Select-A-Spring list. Keep it handy as a time-saving, useful spring service.*

**Associated Spring Corporation** General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
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Cleveland Sales Office, Cleveland, Ohio
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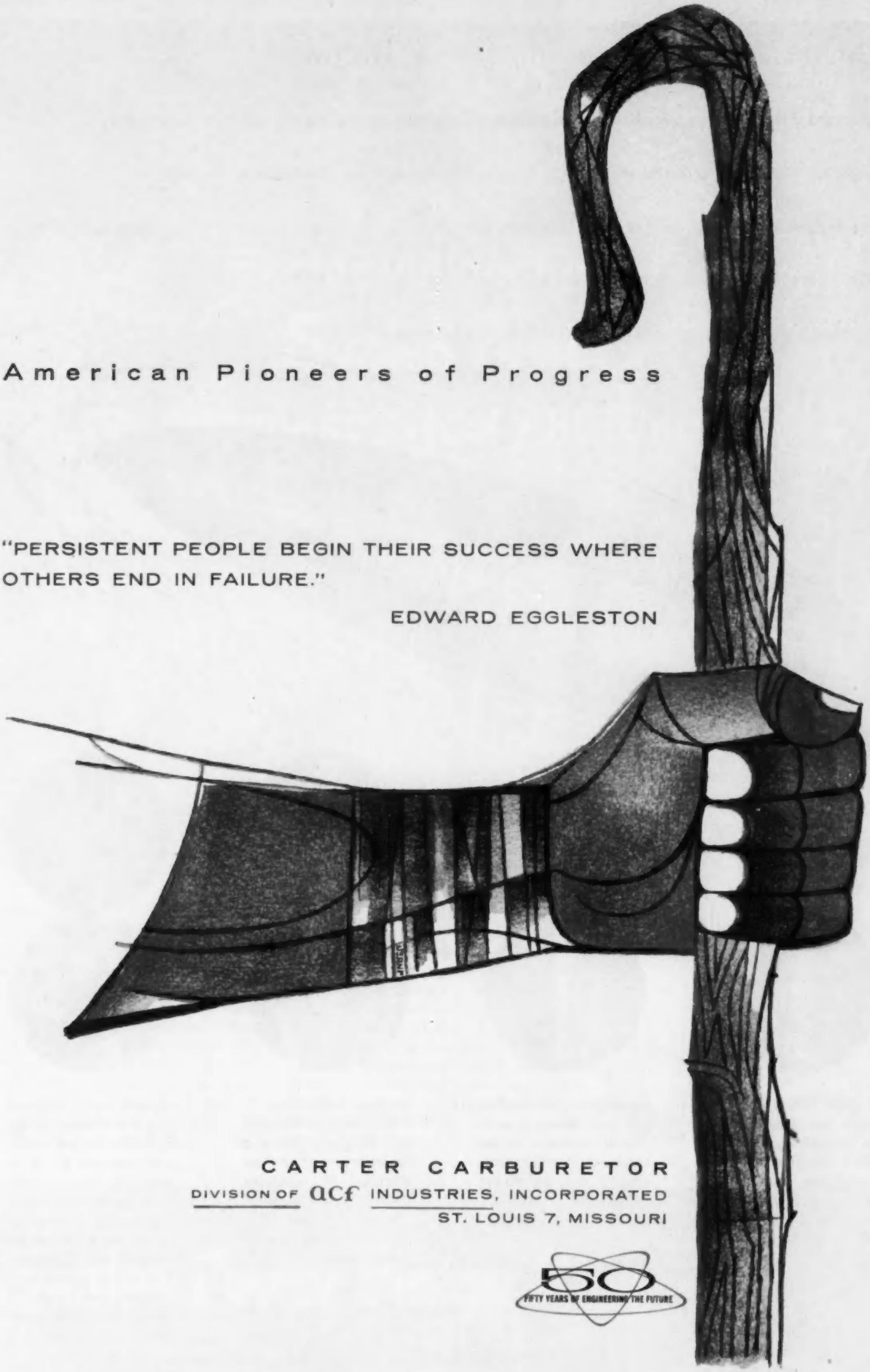
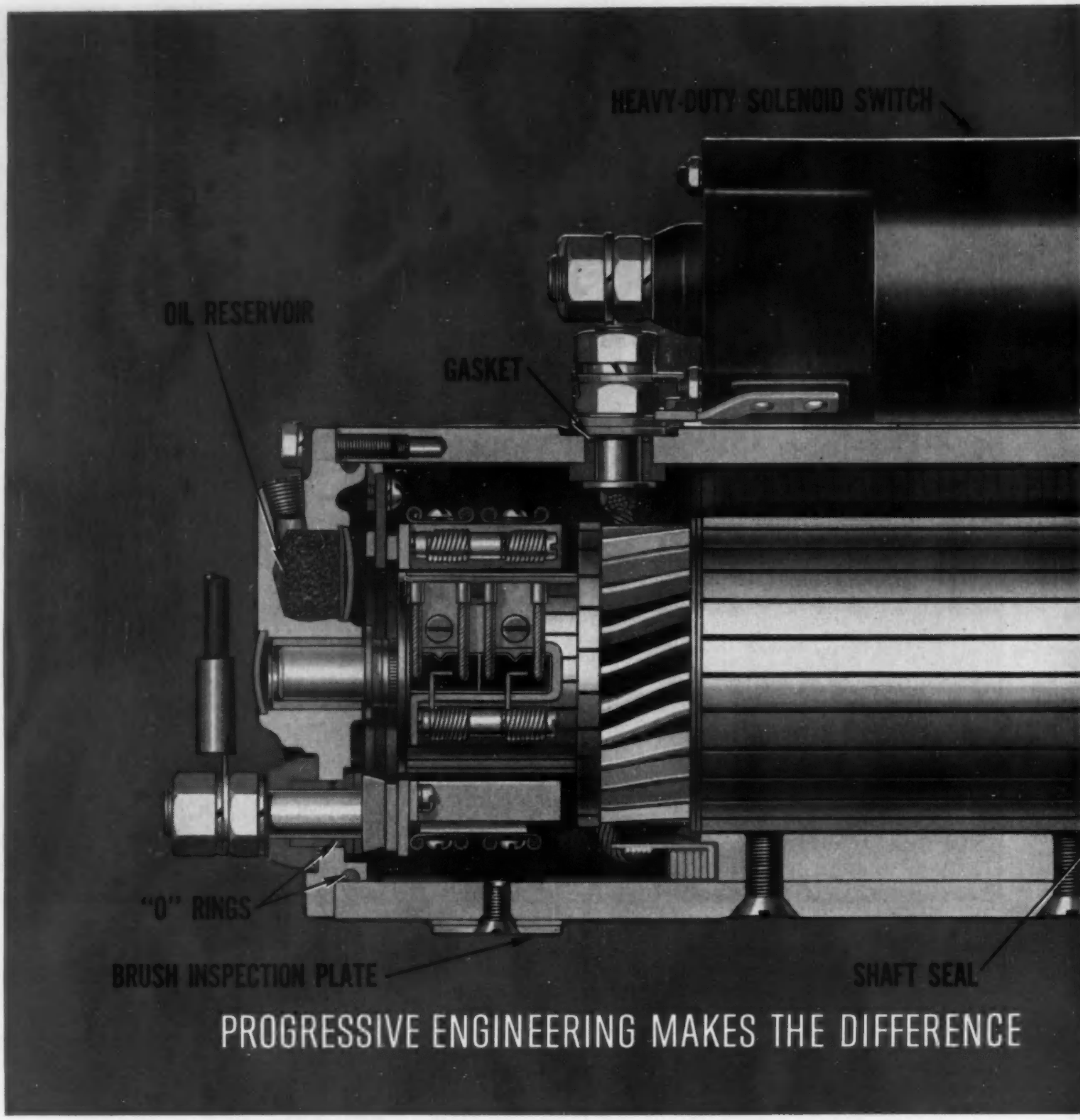
Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

5907



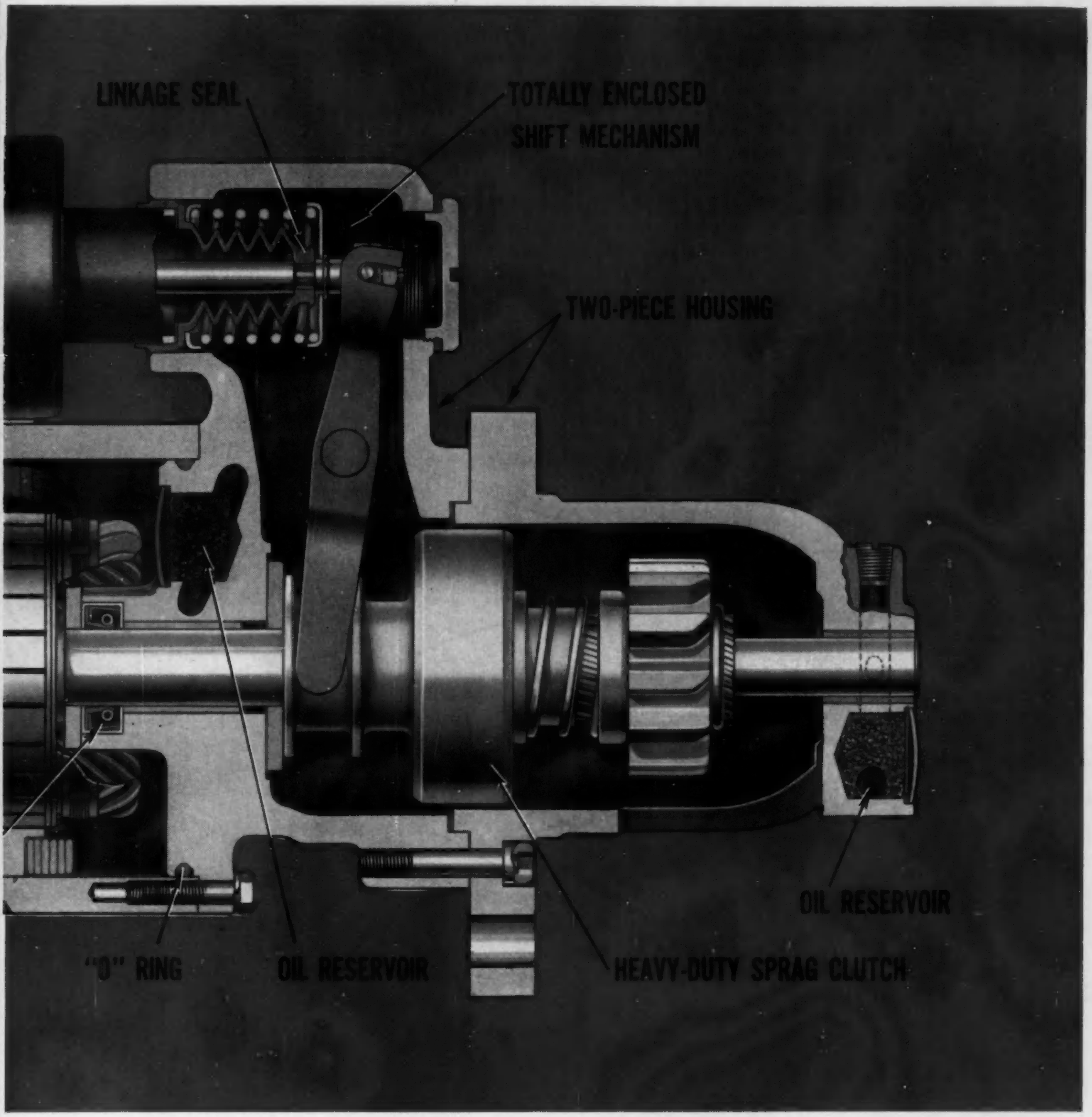



# ANNOUNCING THE NEW DELCO-REMY TOTALLY

Delco-Remy now offers a completely new series of solenoid-operated, over-running clutch type heavy-duty cranking motors with the shift mechanism entirely enclosed. Special two-piece drive housings can be assembled to permit a total of 24 different solenoid positions with respect to motor mounting. New 50% longer brushes, together with sealing rings (optional) and large oil reservoirs (optional), assure extra-long operating time between overhauls. And Delco-Remy design features keep these heavy-duty cranking motors positively engaged until the engine starts. Engine manufacturers are invited to write directly to Delco-Remy for complete information and engineering assistance on the application of these new motors.

TOTALLY ENCLOSED DRIVE SHIFTING MECHANISM is protected against dirt, water, slush and ice. This enclosure plus the shaft seal and linkage seal also prevents transmission oil leakage.

TWO-PIECE DRIVE HOUSING DESIGN permits 24 different solenoid positions. Nose housings available in S.A.E. #2 and #3 mountings.




# ENCLOSED HEAVY-DUTY CRANKING MOTORS

HEAVY-DUTY SOLENOID AND SWITCH provide positive pinion engagement and safely handle maximum starting current. Special seals increase contact life.

SPRAG CLUTCH DRIVE operates with non-chamfered ring gear. Pinion indexes on spiral spline, positively engages ring gear before power switches on, and does not become disengaged with sporadic engine firing.

HEAVIER BRUSH INSPECTION PLATES resist damage from use and handling—are sealed to prevent leakage to motor interior.

GENERAL MOTORS LEADS THE WAY—STARTING WITH

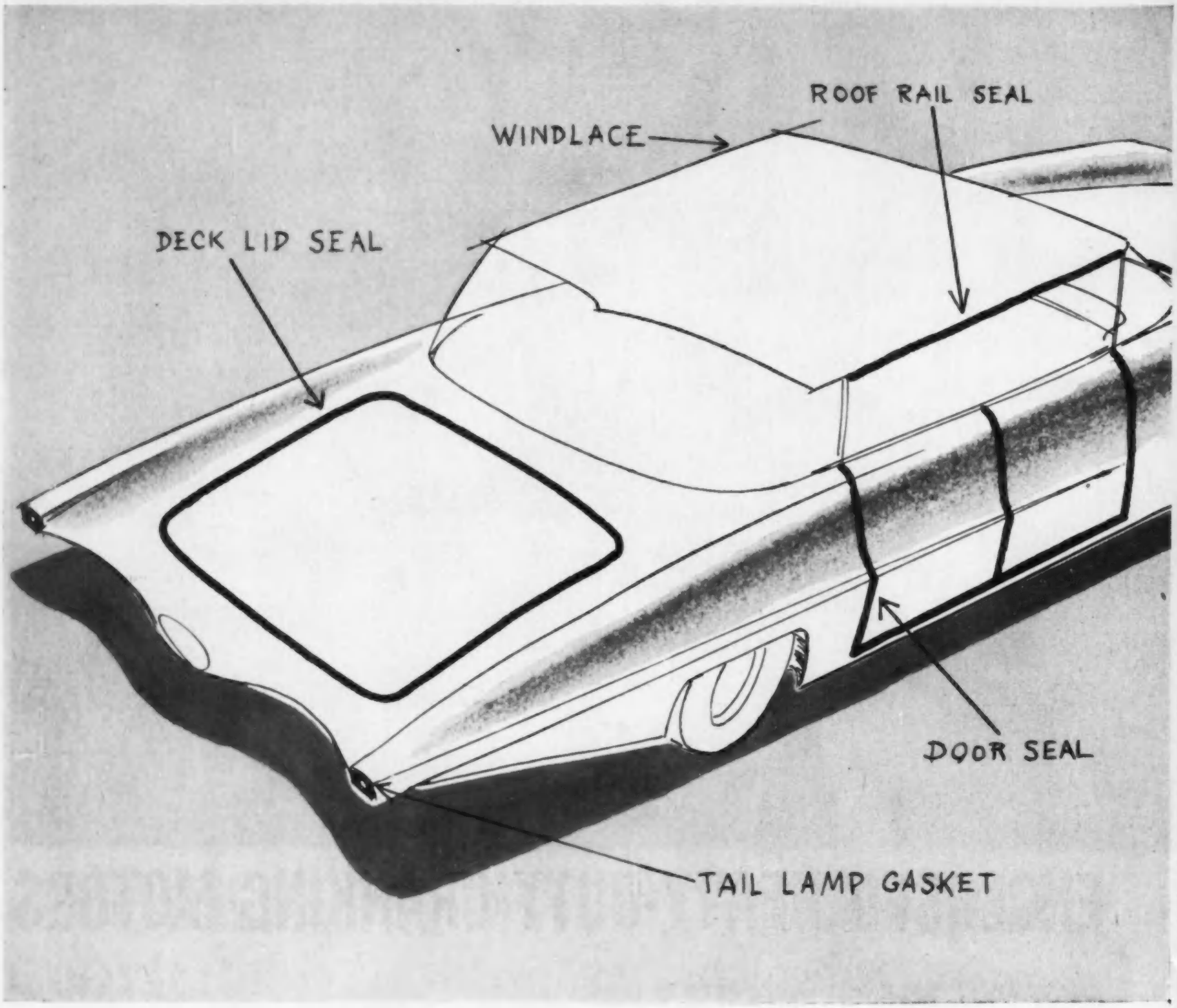
Delco-Remy

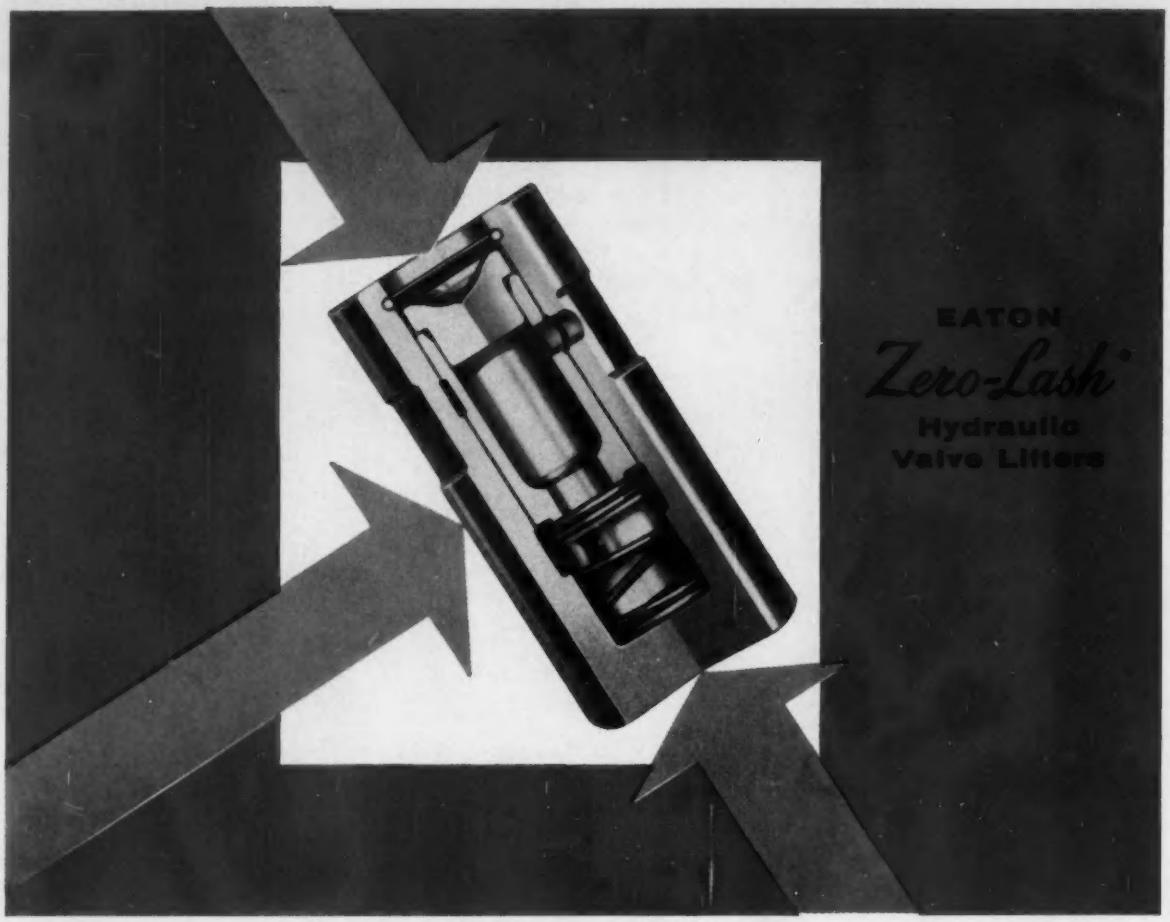
GM GENERAL MOTORS

ELECTRICAL SYSTEMS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

# For improved body seals at lower cost: extruded closed-cell neoprene sponge






# A Hydraulic Valve Lifter Has How Many Sides?

You're *right*—the *inside* and the *outside.* Each is as important as the other—and each has received equal consideration and study from Eaton engineers in developing lifters that will meet the exacting requirements imposed by current engine designs. INSIDES that will continue to operate under difficult sludge and varnish conditions; OUTSIDES that are compatible with today's valve-gear load, speed, and lubrication problems.

Eaton pioneered the first Zero-Lash Hydraulic Lifters back in 1933. Since that time our engineering laboratories and experimental departments have worked continuously to solve the problems inherent in each new engine design—consequently Eaton lifters deliver long, dependable service.

The benefit of Eaton's many years of experience with hydraulic lifters is at your disposal. Call on us.

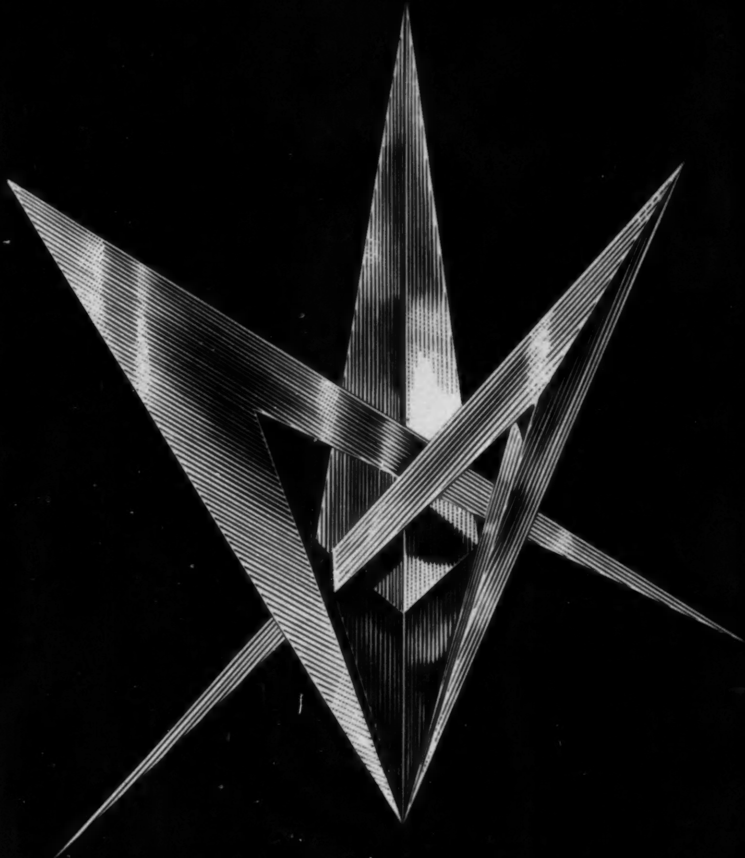
EATON®

**EATON**

SAGINAW DIVISION

MANUFACTURING COMPANY

9771 FRENCH ROAD • DETROIT 13, MICHIGAN



# QUALITY IN STAINLESS STEEL

"FLIGHT OF PROGRESS"
a stainless steel sculpture by Robert Edward Hamilton

Quality in stainless steel starts in the melt shop, where Industry Standards are met – *or missed.*

1 out of every 7 tons of stainless used in the last 15 years came from the melt shop of J&L's Stainless and Strip Division. To achieve that remarkable record as a supplier of semi-finished products, J&L set up its own standards and specifications – far more exact, more precise, *more rigid* than those in general use. Today J&L leads the industry in melting practice standards – the point where quality starts.

Chances are 1 out of 7 you have already enjoyed J&L quality in stainless, without knowing its melt shop origin. Now you can eliminate chance! Newly installed cold rolling and finishing equipment in operation at Louisville, Ohio, makes J&L the most modern *integrated* source for *finished mill products* – stainless sheet, strip, bar and wire. All of traditional J&L stainless quality.

On your next stainless steel order specify "J&L *Consistent* Quality." Don't pay for less.

*Plants and Service Centers:*
*Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit*

J&L
**STAINLESS**
**SHEET • STRIP • BAR • WIRE**

**Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34**

Hydraulic Impulse Machine "road-tested" Morse Timing Chain and other chains at the equivalent of 95 mph. For results, see below.

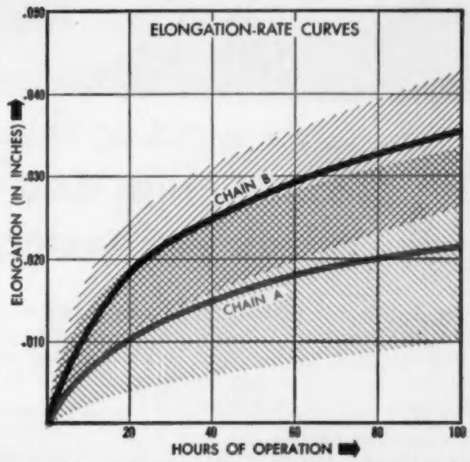
# Hundred-hour "stretch test" at 95 mph proves Morse Timing Chain 24% better!

**In lab test at 4000 rpm under 90-lb. load Morse Timing Chain elongates 24% less than second-best timing chain**

The graph at right shows how Morse Timing Chain resists elongation better, even under severest operating conditions. No wonder Morse Timing Chain has been specified for over 80,000,000 car engines.

Today's high-horsepower engines demand split-second timing for top performance. So Morse builds each timing chain like a fine watch; inspects it carefully with modern equipment to insure *extra* thousands of trouble-free miles.

For original equipment or replacement timing chains, it pays to contact Morse *first*. Get full information and practical engineering help. Call, write or wire today: MORSE CHAIN COMPANY, DETROIT, MICHIGAN; ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois.

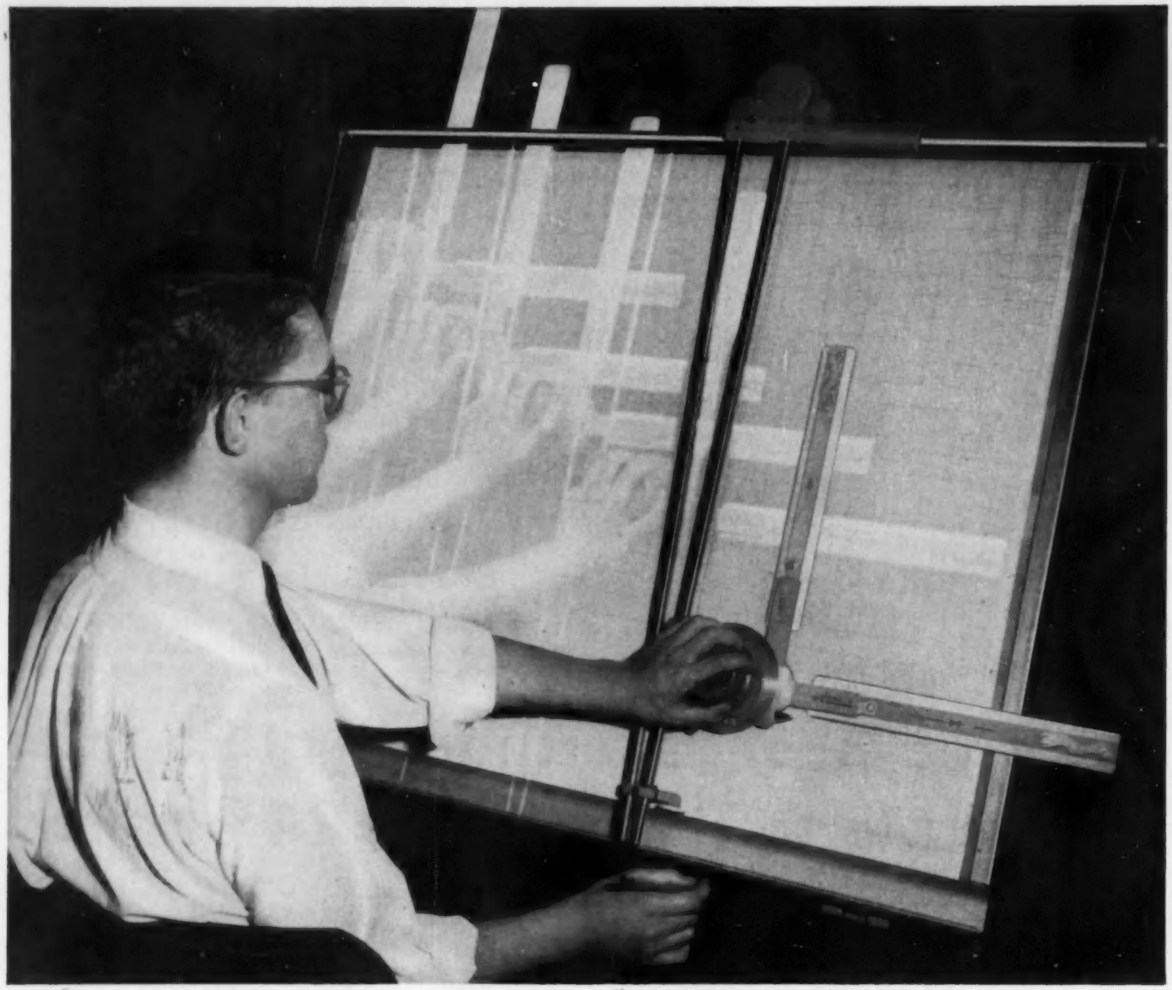



Morse 53-121 Timing Chain (A) showed 24% less elongation than other chain (B), after 100 hours at 4000 rpm under a 90-lb. load on the Hydraulic Impulse Machine—a very severe test that has been correlated with road and dynamometer test runs.

SERVING THE AUTOMOTIVE INDUSTRY FOR OVER 55 YEARS

MORSE* A BORG-WARNER INDUSTRY

*Trademark



# ADVANCED DESIGN PISTONS

## By GILLETT AND EATON

## for Longer Heavy Duty Service


## TROUBLE-FREE with thousands in use

★ Low initial cost ★ Low cost per mile
★ Amazing increase in piston life
★ Maintains new engine power and performance

### G and E WIRE INSERTS PUT CAST IRON WEAR IN TOP RING GROOVE

G and E Wire Insert Piston before machining (left) and after ring grooves are cut (right) showing how the steel wire forms a tough wear-resisting surface on both faces of top ring groove. The patented ferrous plug molded in the head (for diesel pistons) prevents burning through head and lengthens diesel piston life!

With the thousands of G and E "Wire Insert" Pistons in use for periods up to 3 years—a phenomenal record for trouble-free operation has been established. The "Wire Insert" greatly reduces top ring groove wear and increases piston life.

The "Wire Insert" piston design—exclusive with G and E—combines all the advantages of aluminum alloy pistons with the long life of steel in the top ring groove lands. No noticeable increase in weight—unequalled for rapid heat flow—and at low cost.

A pre-shaped steel wire is cast into the piston where the top ring is located. When the grooves are machined, the closely spaced wire surfaces form hard bearing areas on top and bottom faces of the groove. Result—reduced ring land wear, longer piston life at lower cost.

*Get the G and E Wire Insert story today.*

## as LIGHT as aluminum ... wears LIKE IRON

# VANASIL*

### "OIL-ABSORBING" PISTONS

### FOR GASOLINE AND DIESEL ENGINES

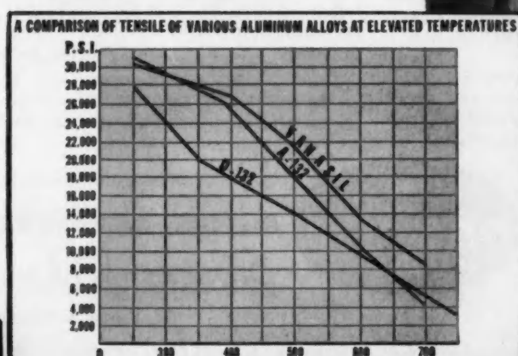
*Gillett & Eaton's trademark for a vanadium... high silicon... aluminum alloy.

**VANASIL** Pistons have repeatedly run way over 200,000 miles with only .002" to .005" wear on the top ring grooves. On-the-road ring breakdowns caused by badly worn grooves are almost eliminated because *Vanasil Pistons reduce top ring groove wear up to 75%!* Nothing else compares with the genuine G & E Vanasil—the original high silicon alloy, proven by 19 years of use.

### You Get ALL These Advantages Only In GENUINE VANASIL PISTONS

**G & E PROVED Vanadium ... High Silicon ... Aluminum Alloy**

1. LIGHT WEIGHT—Same as other aluminum alloys.
2. SCORING, SCUFFING MINIMIZED—Because of "Oil Absorbing" microscopic porous texture.
3. LONGER LIFE—30% less friction—30% harder. Greater "hot strength"—see chart at right.
4. TOP RING—Breakage virtually eliminated because of reduced ring groove wear.
5. LOW EXPANSION—Characteristics of Cast Iron.
6. CLOSE CLEARANCES—Fitted with Cast Iron Clearances.
7. SOLID SKIRT DESIGN—No expansion devices required.
8. HIGH HEAT CONDUCTIVITY—Similar to other aluminum alloys.
9. PLATING—No tin or other break-in coating required.

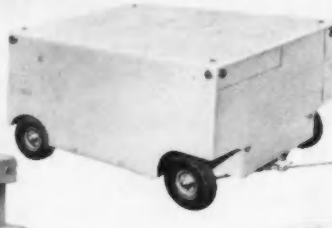



Write for complete information and prices on Gillett and Eaton's Wire Insert and Vanasil longer lived pistons.

*"Our 90th Anniversary Year"*

**GILLETT and EATON, Inc.** 853 DOUGHTY STREET LAKE CITY, MINNESOTA

Truck installations supply pneumatic power for main engine starting, cooling and heating, electrical power for commercial jet powered airliners.



Dual carts for main engine starting, air conditioning and electrical power for military aircraft.

# Reliable and versatile ground support

AiResearch MA-1A trailer for starting military aircraft. Nearly 2,500 in the field.

Air transportable pod for engine starting, cooling of electronic equipment and pre-flight checkout for military aircraft.

Lightweight Freon system, usually installed in a van or trailer, for cooling electronic equipment in support of missiles.

***AiResearch ground support equipment is tailored to meet turbine powered aircraft and tactical missile requirements. Lightweight, compact units can be designed to specific configurations or installed on standard vehicles.***

Heart of the lightweight ground support systems are AiResearch gas turbine compressor power units. Capable of delivering both electrical and pneumatic power, nearly 8,000 of these units are operating successfully and dependably in the field.

Support services can include: main engine starting, pressurization and air conditioning of cabins and compartments, missile pre-flight check-out, removal of snow and ice from aircraft and equipment, supply of DC or AC electrical power at any required frequency, and low pressure, high flow air for operation of a variety of actuation systems. The units have push-button starting and operate without delay under all weather conditions.

The world's largest producer of lightweight turbomachinery, the AiResearch Manufacturing Divisions are prepared to assume complete systems management responsibility for your ground support requirements.

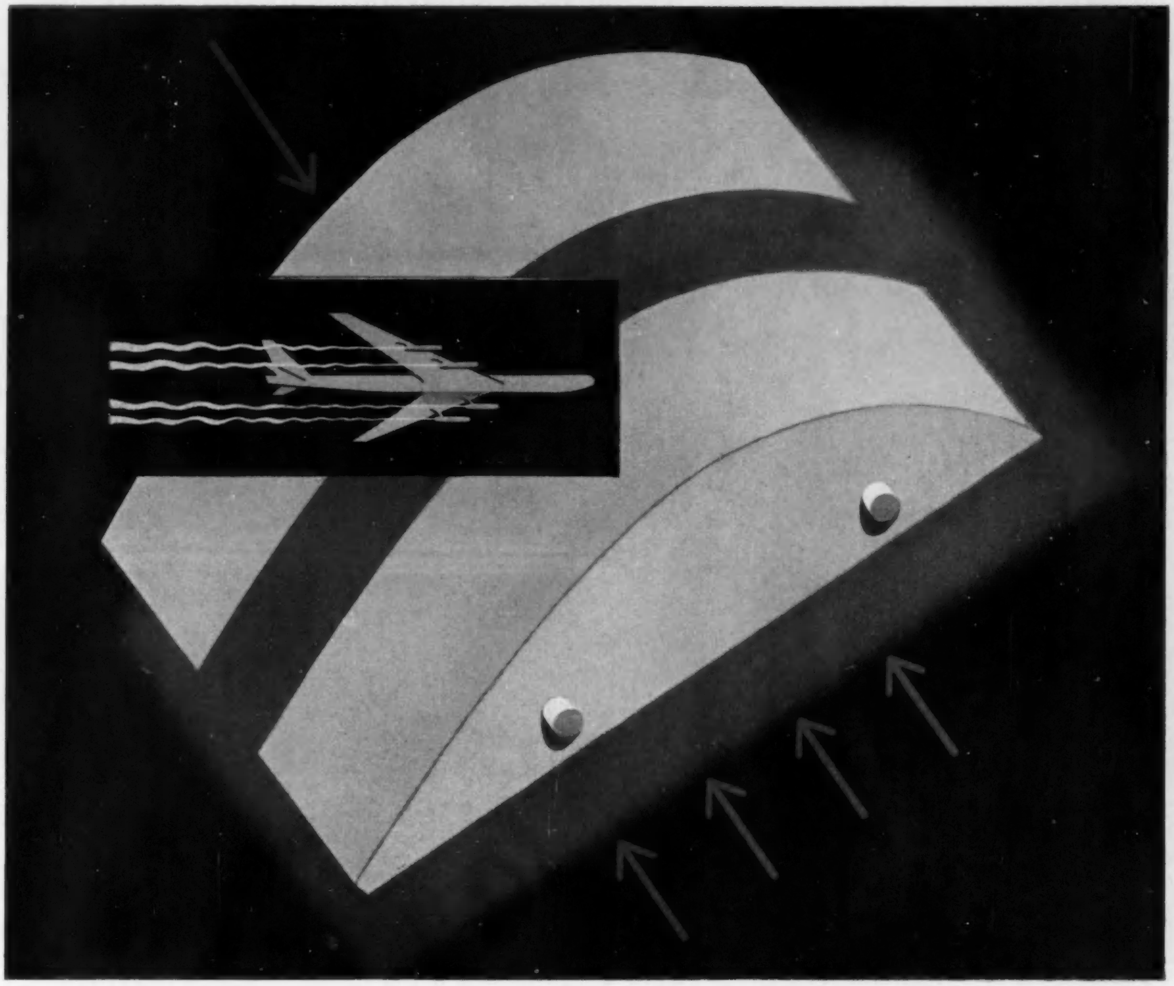
ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

**THE GARRETT CORPORATION**

**AiResearch Manufacturing Divisions**

*Los Angeles 45, California • Phoenix, Arizona*

*Systems, Packages and Components for:* AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS



# Save up to 30% in cost, 60% in time with EPON* RESIN tools and dies

Your tooling resin formulator will show you how Epon resin formulations save time and money in applications such as these:

**High temperature tooling:** Metal forming stretch dies that can operate at temperatures over 400°F.

**Heated tools:** Matched dies, with integral heating units, may be made with Epon resin formulations for rapid heat curing of laminated plastic parts.

**Long-lasting metal forming tools:** Castings made of formulated Epon resin, mounted in a crank press, showed no permanent deformation after 28,000 compression-shock cycles.

In addition, Epon resin formulations offer you the following advantages:

**Excellent tolerance control:** Little machining and handwork are required to finish Epon resin tools because of the material's excellent dimensional stability and lack of shrinkage.

**Outstanding strength:** Jigs and fixtures with thin cross sections can be built from Epon resin-based formulations reinforced with glass cloth. The resulting laminate has high flexural strength and excellent dimensional stability.

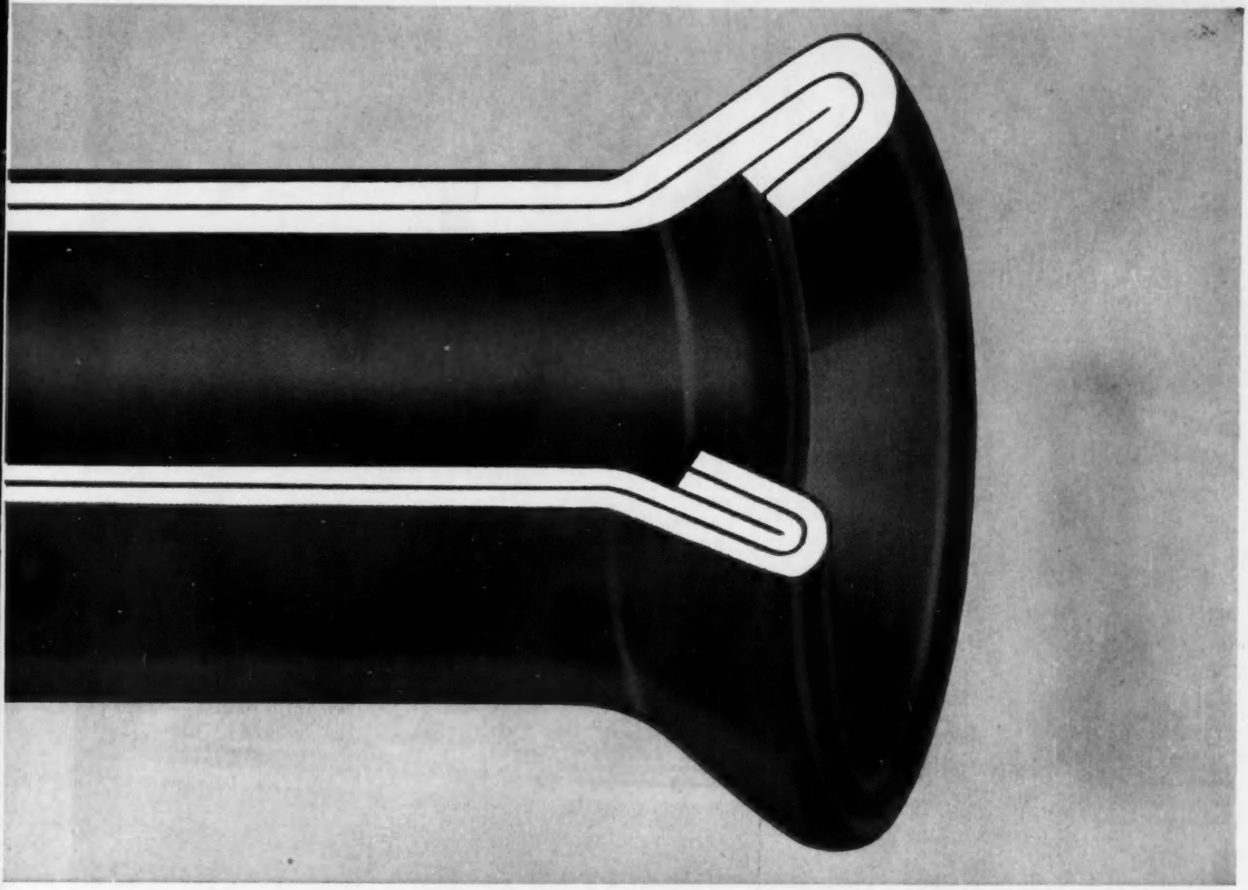
**Easy modification:** Tools and fixtures made from Epon resins may be quickly and easily modified to incorporate design changes.

## CONTACT YOUR TOOLING RESIN FORMULATOR

The combination of resin formulator's skill and practical knowledge, backed by Shell Chemical's technical research and experience, has solved many important tooling problems for industry. Your own formulator specialist can help you solve yours. For a list of experienced tooling resin formulators and additional technical information, write to:

**SHELL CHEMICAL CORPORATION**
**PLASTICS AND RESINS DIVISION**
**50 WEST 50th STREET, NEW YORK 20, NEW YORK**

CHICAGO · CLEVELAND · LOS ANGELES · NEW YORK
IN CANADA Chemical Division, Shell Oil Company of Canada, Limited, Montreal • Toronto • Vancouver



Cutaway of Bundy double flare (greatly magnified) that puts almost *twice* the metal at the seat.

# insures extra brakeline safety

This is the famous Bundy® double-flare—developed to take high wrench-torque and frequent uncouplings . . . and still carry high-pressure hydraulics *with perfect safety*. It's just one example of how Bundy leads in *mass-fabrication* these three ways:

**1. The tubing itself**—Bundyweld®, double-walled from a single steel strip. It stands up against brutal shocks and vibration fatigue. That's why it's on 95% of today's cars, in an average of 20 uses each.

**2. Bundy design service**—Skilled engineers are on call at any stage in the development of your product. Often they'll suggest short-cuts to trim costs.

**3. Bundy fabrication service**—Trained technicians man Bundy-designed machines . . . turn out parts to your specifications at lowest unit cost.

**Add it up**—then check *first* with Bundy for the finest in small-diameter tubing plus unmatched design and fabrication service. Contact us today!

**BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN**

***WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY***

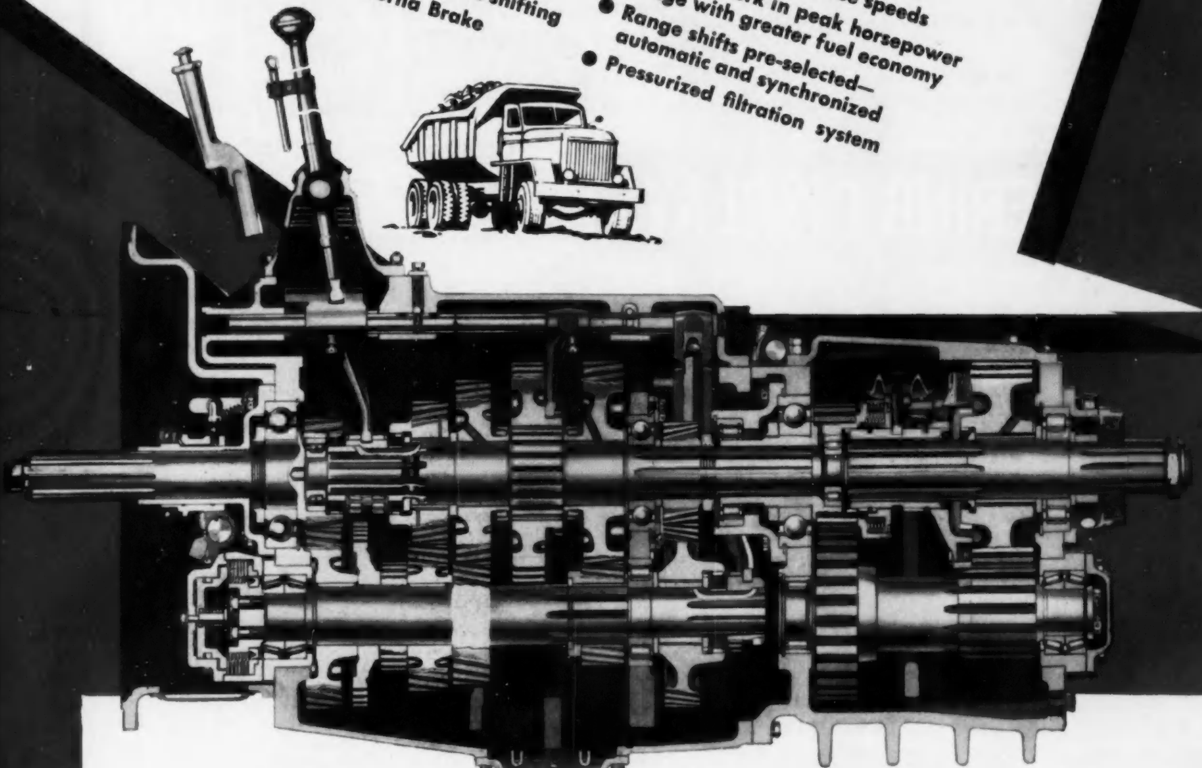
*There's no real substitute for*

**BUNDYWELD® TUBING**

**Bundyweld and Bundy specialty tubings are sold through distributors in principal cities**

# THE R-1160 PROVIDES THESE ADVANTAGES

- No gear splitting—9 selective gear ratios are evenly and progressively spaced
- Easier, quicker shifts—38% steps between ratios
- Less driver fatigue—⅓ less shifting
- Countershaft Inertia Brake
- One shift lever controls all 9 forward and 2 reverse speeds
- Engines work in peak horsepower range with greater fuel economy
- Range shifts pre-selected—automatic and synchronized
- Pressurized filtration system



## VITAL STATISTICS

| GEAR | RATIOS | % STEP | |
|---|---|---|---|
| Ninth | .75 | 33 | HIGH RANGE |
| Eighth | 1.00 | 39 | |
| Seventh | 1.39 | 40 | |
| Sixth | 1.94 | 34 | |
| Fifth | 2.59 | | |
| RANGE SHIFT | | 34 | |
| Fourth | 3.48 | 39 | LOW RANGE |
| Third | 4.84 | 40 | |
| Second | 6.76 | 34 | |
| First | 9.02 | | |
| Reverse | 3.31 | High Range | |
| Reverse | 11.53 | Low Range | |

WEIGHT: 1133 lbs. LENGTH: 44²¹⁄₃₂" OIL CAPACITY: 35 pts.; with filter, 38 pts.
CLUTCH HOUSING SIZE: SAE No. 1 APPROXIMATE ENGINE SIZE, CU. IN.: 1160

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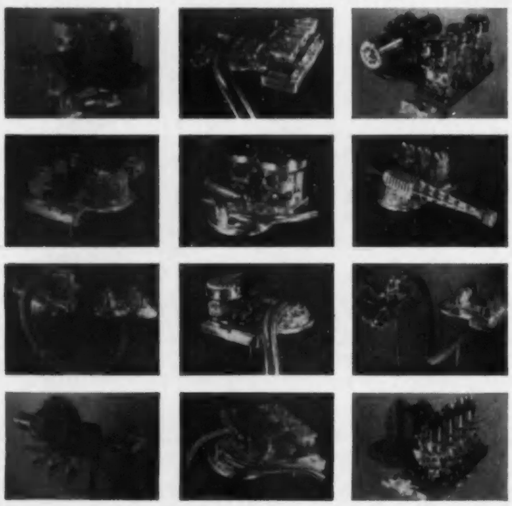

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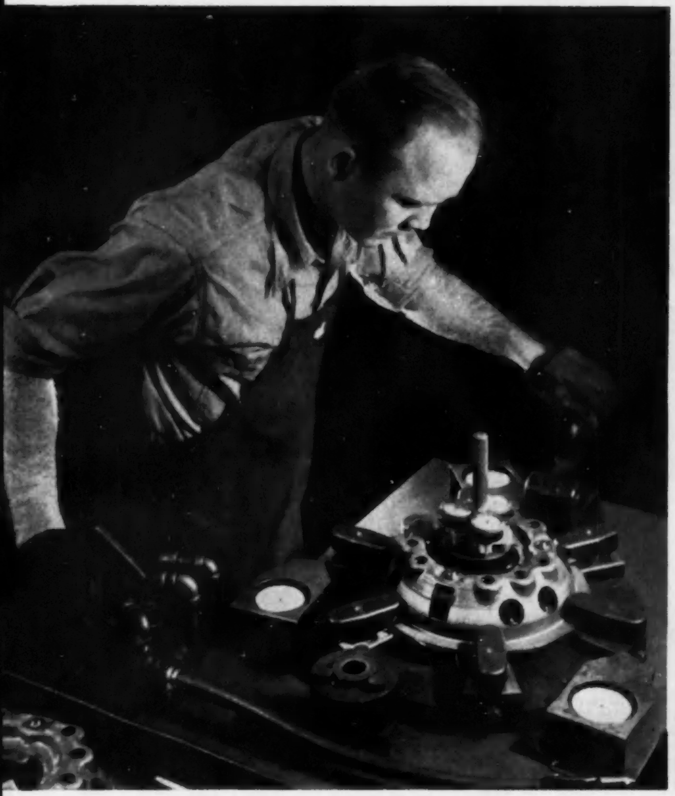

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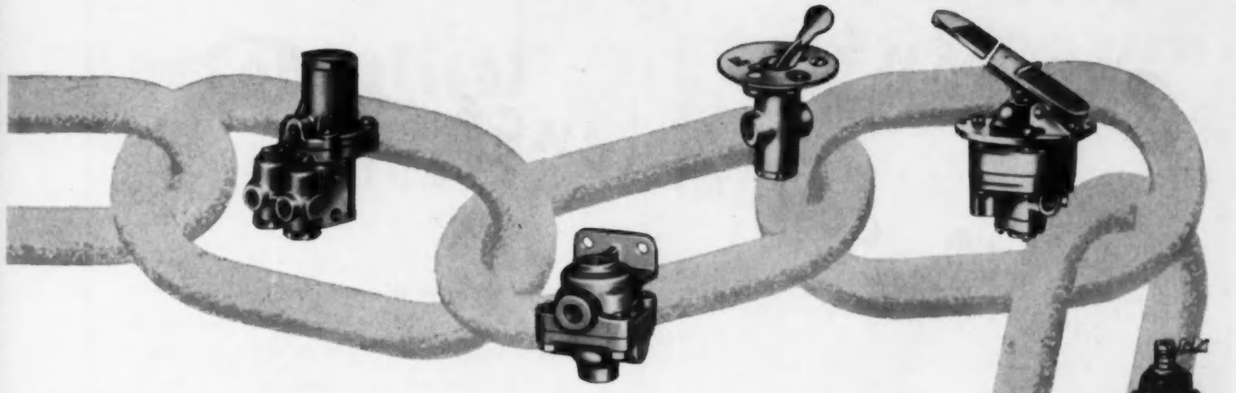

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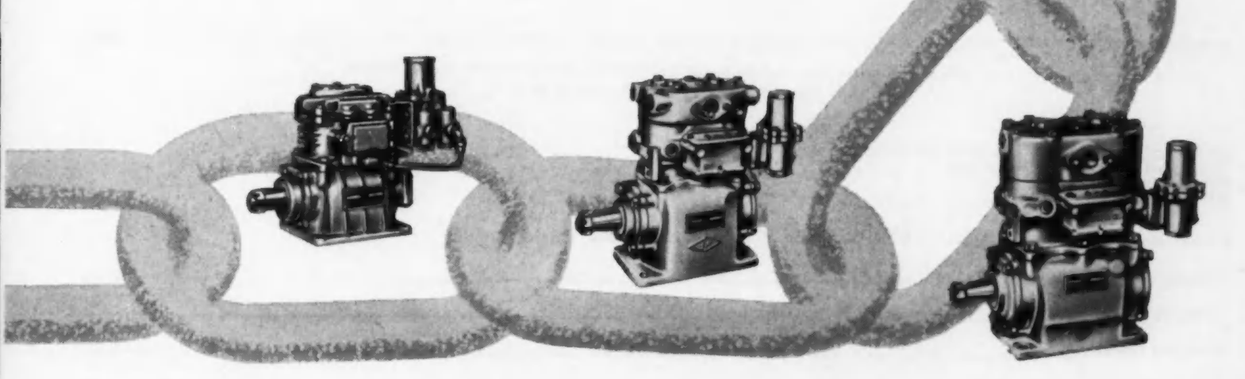

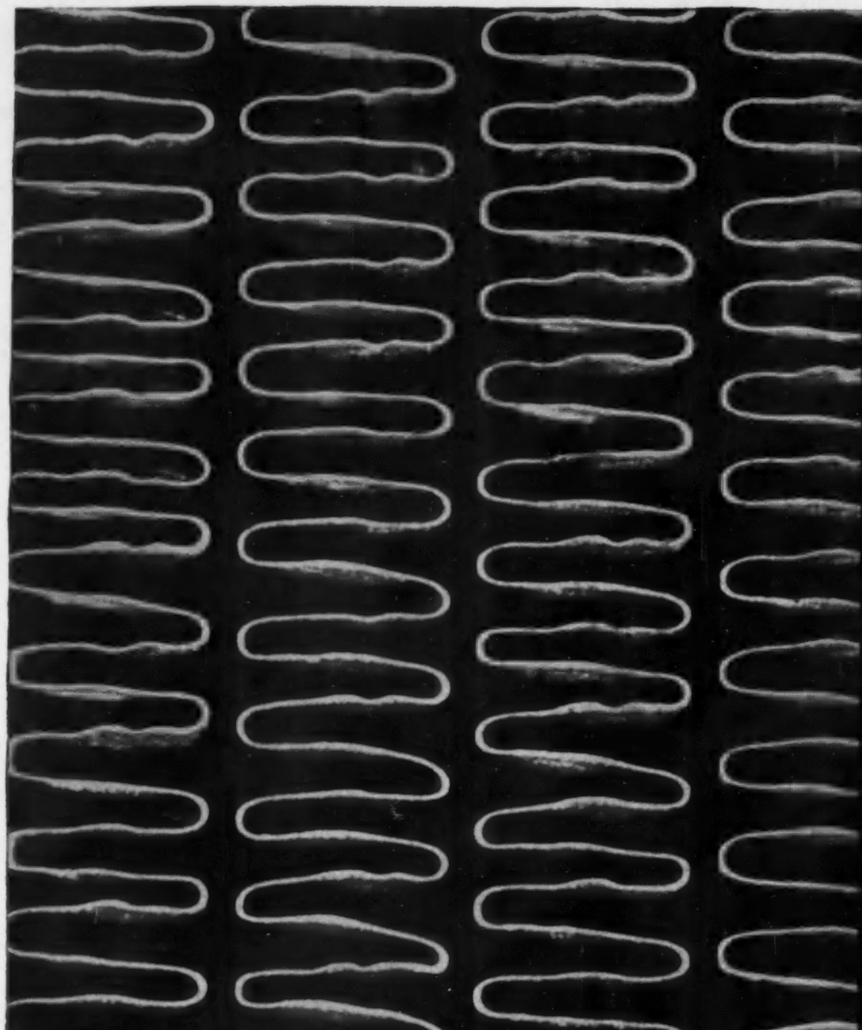

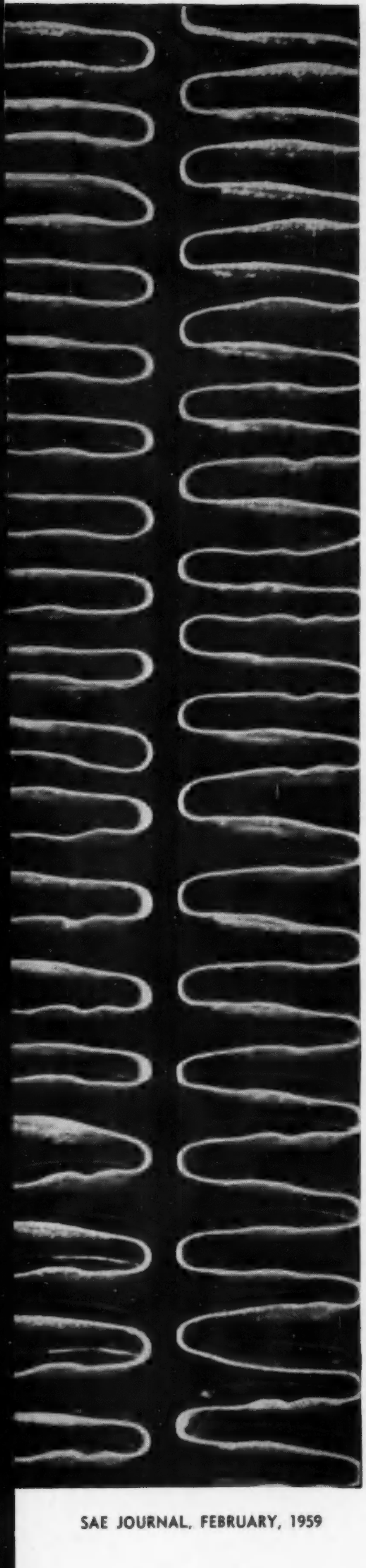



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